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# The Nexus between Formal Credit and E-Commerce Utilization of Entrepreneurial Farmers in Rural China: A Mediation Analysis

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**Abstract:** E-commerce furnishes farmers in rural China with a novel solution accomplishing entrepreneurship transformation, but serious credit constraints still coexist with it at present, which may restrict the release of e-commerce's potential. Therefore, this study investigates whether formal credit promotes entrepreneurial farmers' e-commerce utilization and explores its influencing mechanism. Based on the survey data collected from 831 entrepreneurial farmers in Shaanxi province, Ningxia province and Shandong province in rural China, the propensity score matching (PSM) method was applied to measure the impact of formal credit on e-commerce utilization. The results show that formal credit contributes to a 18.41% increase of e-commerce utilization in general and increases entrepreneurial farmers' online purchases and sales by 11.15% and 14.69%, respectively. Some groups perform significantly in the heterogeneity analysis, the most noteworthy of which are entrepreneurial farmers who are younger, belong to new type of agricultural business entities and use mobile payments. Their e-commerce utilization, including online purchases and sales, are impacted most by formal credit. Furthermore, when the bootstrap method was used to examine the mediating effect, we found that formal credit has a positive and significant effect on the utilization of e-commerce through four channels, which are internet learning, asset allocation, labor allocation and income growth. Hence, the findings suggest that the government should augment the amount of formal credit to optimize entrepreneurial farmers' internet learning, asset allocation, labor employment and income growth, thereby promoting e-commerce to achieve entrepreneurial transformation and sustainable development in rural areas.

**Keywords:** e-commerce utilization; formal credit; mediation effect; entrepreneurial farmers



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## 1. Introduction

Rural innovation and entrepreneurship are momentous practices for implementing the strategy of rural vitalization in China [1]. With the in-depth advancement of “Widespread Entrepreneurship and Innovation”, Chinese farmers' entrepreneurship has entered the bottleneck period, especially due to a capital investment shortage, long payback periods and high risks of failure [2]. The problems of aggravated entrepreneurial vulnerability, lower survival rates and the weak ability of sustainable development urgently require rural entrepreneurial farmers to take the optimal steps for transformation [3]. Fortunately, with the continuous improvement of digitalization and informatization, e-commerce, as an emerging type of business trading activity model, has developed rapidly and penetrated rural areas profoundly [4,5].

E-commerce is beneficial to farmers' entrepreneurship in numerous aspects. Firstly, it can reduce transaction costs [6], alleviate information asymmetry [7] and optimize resource allocation [4]. Secondly, e-commerce and online businesses provide new ideas, strategies and opportunities for entrepreneurial farmers in economic decision making of production

and sales [8]. In addition, farmers can play a dual role in e-commerce activities. On the one hand, some e-commerce platforms sell agricultural raw materials, like “Yun Nong Chang” and “Nong Yi Wang”, which alleviate information asymmetry and cut down circulation costs by simplifying the hierarchical agency [6,9,10]. Entrepreneurial farmers can compare products and make diversified choices, helping farmers to adjust their production strategies flexibly and improving their entrepreneurial performance by controlling the purchase cost of production materials via an e-commerce platform [11]. On the other hand, entrepreneurial farmers can use third party e-commerce platforms, such as “Rural Taobao” and “JD.com”, and social media, such as friend circles on WeChat and QQ, to sell products. These breakthroughs unlock territorial restrictions, reach the maximal number of potential customers and reduce the risk of unsaleable products [12,13], thereby resulting in increasing sales and profit margins to arouse the farmers’ enthusiasm for entrepreneurship [14]. Therefore, e-commerce has become a new alternative for entrepreneurial farmers to control their operating costs and risks; at the same time, e-commerce also increases their expected economic benefits [15].

E-commerce in rural areas has been paid a high amount of attention and has been supported by China’s Central Government. At present, the condition of mobile communication and Internet in rural China is evolving rapidly according to China Internet Network Information Center. Concrete manifestation in the scale of rural netizens is continuing to grow, and the level of rural network technology is gradually approaching that of cities [16]. In addition, the coverage of the logistics distribution service system in rural areas keeps expanding and the construction of transportation is being upgraded rapidly and increasingly. The logistics infrastructure combined with the express delivery industry provide a solid foundation for entrepreneurial farmers to adopt e-commerce [17,18]. However, electronic equipment configuration, storage facility construction, the participation of e-commerce platforms and the employment of technical experts all require funding support, which is the major hurdle restricting entrepreneurial farmers’ utilization of e-commerce [19,20].

Farmers’ financing channels are mainly composed of formal credit and informal credit in rural China [21,22]. Informal credit refers to financial lending activities outside the scope of government supervision, which encompasses huge risks [23]. Burgeoning internet credit platforms, such as P2P and Ant Finance, also provide farmers with new financing methods [24,25]. However, in view of the current Chinese rural reality, entrepreneurial farmers are still excluded from using the emerging financing methods due to their cognition and risk perception [26]. The impact of formal credit on rural areas is becoming more and more profound with the reform of rural financial system and the improvement of formal credit institutions’ services. The main funding channels are still postal savings banks and rural credit cooperatives [27]. Therefore, exploring the relationship between formal credit and entrepreneurial farmers utilization of e-commerce offers a practical reference to ease the liquidity constraints of farmers’ entrepreneurial transformation and get out of the dilemma of rural e-commerce development.

Entrepreneurship not only has been as a potential tool for alleviating rural poverty to improve farmers’ wealth and happiness [28,29], but also accelerates economic growth, optimizes industrial structure and promotes economic transformation in rural China [30]. Main factors influencing farmers’ entrepreneurship, for example, risk attitude, credit constraints and social capital have been greatly researched [2,31,32]. However, in recent years, entrepreneurship in rural China has been experienced great changes. In particular, e-commerce has made great progress. Some scholars have studied the factors influencing entrepreneurs’ e-commerce participation. Cloete and Doens [33] found that 55.4% of the surveyed agricultural enterprises had adopted e-commerce; the results of their regression analysis showed that the cognition of e-commerce and technical facilities significantly affected enterprises’ willingness to adopt e-commerce. Molla et al. [34] applied the integrated model to demonstrate that technological competence, financial commitment, perceived environmental e-readiness and organization size have a direct impact on agricultural enterprises’ utilization of e-commerce; in addition, perceived organization e-readiness has an

indirect influence on their use of e-commerce. Rahayu and Day [35] found that perceived benefits, technology readiness and owners' innovativeness, IT ability and IT experience are the major determinants of e-commerce adoption among small and medium enterprises.

Many other studies have focused on the attributes of e-commerce and farmers' characteristics. Compared with traditional commerce, the risks brought by e-commerce affect farmers' behavior regarding online purchasing [14,36,37]. Walsh et al. [38] suggested that a positive reputation in an e-commerce setting weakens farmers' risks perception and engenders trust. Furthermore, the quality of service experience has been found to influence farmers' e-commerce satisfaction [39]. Batte and Ernst [40] provided evidence regarding the importance of delivery in agricultural context, revealing that an ameliorative delivery service influences farmers' online purchase decision. Considering personal characteristics, farmers' age, education level and farm size have an effect on their online purchase decision [41,42]. In addition, farmers' prior experiences might influence their willingness to participate in e-commerce again [43,44]. While there are various studies looking into e-commerce participation among farmers, the amount of empirical literature that has used an econometric methodology to analyze the effect of formal credit on entrepreneurial farmers' e-commerce utilization has been scarce. To fill this gap, the objective of this study is to test the effect of formal credit on entrepreneurial farmers' e-commerce utilization and explore its influencing mechanism of mediating effect. Therefore, we explain the theoretical framework of the impact of formal credit on entrepreneurial farmers' e-commerce utilization. Then based on survey data of 831 entrepreneurial farmers collected from Shaanxi province, Ningxia province and Shandong province, China, firstly, the propensity score matching (PSM) method is used to explore the effect of formal credit on e-commerce utilization including online purchases and sales. Furthermore, we analyze heterogeneity of different groups by age, new agricultural business entities and mobile payment. Finally, the bootstrap method is examined to empirically test mediating mechanism between formal credit and e-commerce utilization. Our study attempts to supplement the existing literature and provide new empirical evidence, especially in the context of China.

The remainder of this study is organized as follows. Section 2 constructs a theoretical framework focusing on the channels through which formal credit affects the utilization of e-commerce. Section 3 describes the data samples and provides a description and summary statistics of the variables used in the study, as well as presenting the model specification of the PSM method and the bootstrap method. Section 4 presents and discusses the empirical results, and the final section provides the conclusions and policy implications.

## 2. Theoretical Framework

Electronic commerce, commonly known as e-commerce, consists of the buying and selling of products or service over electronic systems such as the internet and other computer networks [45]. E-commerce is one potential piece of e-business. E-business covers a wider range and is more focused on internal processes within the organization. There is a difference between the definition of e-commerce and e-business, the latter of which involves lying about the definition of network communication technology. E-business is defined as the use of internet, intranet or extranet, while e-commerce refers to transaction activities of goods and services conducted through internet exclusively [46,47]. In accordance with Zapata et al. [48] and Lin et al. [49], we focus on the most critical production and marketing links in the economic activities of entrepreneurial farmers and comprehensively gauge entrepreneurial farmers' e-commerce utilization focusing on two aspects, namely online purchases and online sales. Entrepreneurial farmers are facing funding constraints involving rapidly increasing demand for agricultural investment in the process of e-commerce transformation [50]. The working capital is often insufficient to cover the development funds required for operations in e-commerce. In the case of insufficient internal financing, entrepreneurial farmers usually consider the financing path of formal credit [51,52]. Therefore, this study formulates the following hypotheses:

**Hypothesis 1 (H1).** *Formal credit participation has a significantly positive impact on entrepreneurial farmers' e-commerce utilization.*

**Hypothesis 1a (H1a).** *Formal credit participation has a significantly positive impact on entrepreneurial farmers' online purchases utilization.*

**Hypothesis 1b (H1b).** *Formal credit participation has a significantly positive impact on entrepreneurial farmers' online sales utilization.*

We construct a theoretical framework to clarify the linkage between credit and e-commerce. In this study, the relationship between formal credit and e-commerce utilization can be explained through four channels: the internet learning effect, asset allocation effect, labor allocation effect and income growth effect. The details are as follows.

The first channel is the internet learning effect, a process of technology adoption, which can directly determine e-commerce utilization. The development of e-commerce in agriculture is strictly linked with the adoption of the Internet [53,54]. In recent years, every bank has developed their mobile banking app, which can be used with smartphones and other mobile terminals, helping customers to handle related banking business. Entrepreneurial farmers who are more familiar with the operation of mobile banking can accumulate more internet knowledge and obtain rich information from the Internet [55]. In addition, various activities in the utilization of e-commerce require farmers to be experienced in using the Internet, such as online purchases of raw materials, information releases on sales products, operation management of online stores and mobile payments for transaction settlement. Thus, proficiency in the use of Internet is essential for entrepreneurial farmers' formal credit participation and e-commerce utilization. This leads to the following hypothesis:

**Hypothesis 2a (H2a).** *Formal credit positively affects entrepreneurial farmers' e-commerce utilization through the mediating effect of internet learning.*

The second channel is the asset allocation effect. The rational allocation of assets is a must-have part of e-commerce decision making, mainly involving the sequence of initial investment, annual reinvestment and investment in fixed assets, such as network machinery and equipment, or logistics warehouse construction. There are also some investments in non-fixed assets, such as online store auxiliary and big data products [48,56]. Besides, financial assets, including insurance, preventive saving and working capital, all are important parts of allocation in farmers' e-commerce utilization [57,58]. The higher amount of formal credit entrepreneurial farmers obtained, the more fixed assets and working capital can be deployed by entrepreneurial farmers to optimize their asset allocation structure in e-commerce utilization [59]. The reasonable asset allocation is directly related to the supply of initial capital and follow-up operating funds for the entrepreneurial transformation. The greater the loan amount, the more helpful it is to increase the flexibility of long- and short-term asset allocation decisions, ultimately affecting the e-commerce selection and the sustainability of the created business. This leads to the following hypothesis:

**Hypothesis 2b (H2b).** *Formal credit positively affects entrepreneurial farmers' e-commerce utilization through the mediating effect of asset allocation.*

The next channel is the labor allocation effect. The well-founded allocation of labor is also an important factor to be considered for e-commerce entrepreneurial transformation [60]. The quantity and quality of labor input, whether to hire e-commerce technical experts and whether to adopt outsourcing service are all aspects of optimizing the labor allocation in e-commerce entrepreneurial transformation. The effortless acquisition of formal credit can mitigate the liquidity constraints and help to pay the corresponding fees. The improvement of the quantity and quality of the labor force can break through the human capital constraints to enhance the flexibility of farmers' choices regarding e-

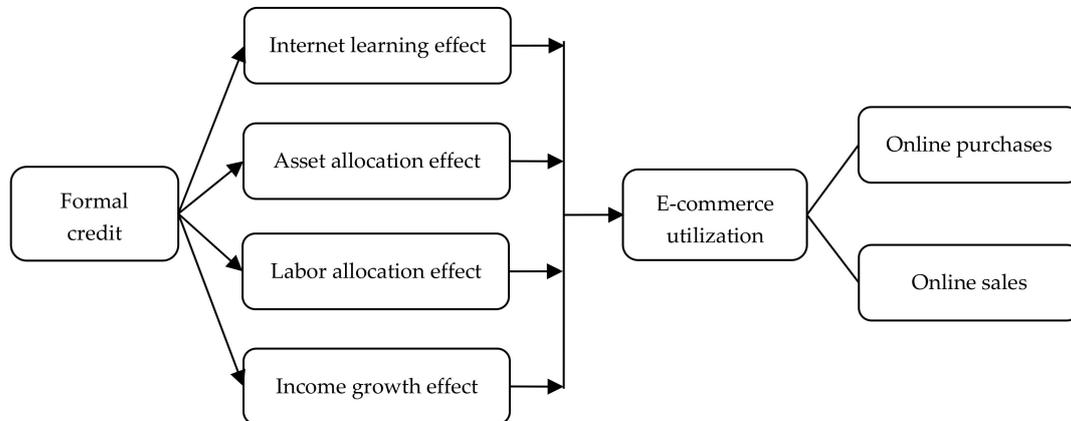
commerce in entrepreneurial transformation. Obtaining formal credit can optimize the labor allocation [61], thereby promoting the transformation of farmers' entrepreneurship and ensuring a healthy operation. This leads to the following hypothesis:

**Hypothesis 2c (H2c).** *Formal credit positively affects entrepreneurial farmers' e-commerce utilization through the mediating effect of labor allocation.*

The last channel is the income growth effect. Income growth is an economic goal that farmers' entrepreneurship cannot overlook [62]. Raising funds to invest in e-commerce is a major motivation for entrepreneurial farmers to apply for formal credit. The investment of credit funds in the e-commerce operation activities of production and sales can ease the liquidity constraints, and promote the adoption of new varieties, new technologies and new equipment. It can aid the steady growth of the production and operation scale to increase the operating income level of farmers and accelerate their wealth accumulation [63]. The increase in the disposable operating income of farmers provides more capital for their entrepreneurship to promote the transformation to e-commerce. Farmers are encouraged to cross the threshold of entrepreneurship actively and implement higher level production and management activities via the Internet. Therefore, formal credit can promote the e-commerce utilization of entrepreneurial farmers by increasing their operation income. This leads to the following hypothesis:

**Hypothesis 2d (H2d).** *Formal credit positively affects entrepreneurial farmers' e-commerce utilization through the mediating effect of income growth.*

The conceptual framework presented above is depicted schematically in Figure 1.



**Figure 1.** Conceptual framework showing that four impact channels of formal credit affecting e-commerce utilization.

### 3. Methodology

#### 3.1. Data Collection

The research team conducted a survey among rural households between January and September 2018 across three provinces in China: Shaanxi, Ningxia and Shandong. The multistage cluster sampling technique was used to choose the sample units. Comprehensively considering the development of rural informatization and a pilot project of migrant farmers returning home to engage in entrepreneurship in China, we selected three counties from each province with different levels of e-commerce development in the first stage. Based on the environmental, economic and geographical conditions, 3 to 4 representative townships were sampled from each county. In the next stage, we selected 2 to 3 villages in each sample township, with 15 to 20 farmers (mainly household financial decision makers) selected subsequently at random from each village, respectively. Finally, a total of 2000 questionnaires were distributed in this survey, and 1947 valid questionnaires were received,

resulting in an initial sample encompassing a total of 105 natural villages in 36 townships, 9 counties, 9 cities and 3 provinces.

The representativeness of the sample selection is described as follows: firstly, Shaanxi province, Ningxia province and Shandong province are major agricultural provinces among western and eastern China, respectively, while their development of advantageous agricultural industries provides favorable support for farmers' entrepreneurship. We also took into account the differences between entrepreneurship pilot counties and general counties. Secondly, according to China's E-commerce Development Index Report (2018), Shaanxi province and Ningxia province are representative provinces for growth-oriented e-commerce development models and Shandong province is a proxy of mature e-commerce development models, so the different levels of development in informatization and e-commerce were considered in our study. Thirdly, the sample set covers agricultural ecosystems varying with different geographic environments, such as the Loess Plateau, Guanzhong Plain, Mountainous Area of Southern Shaanxi and North China Plain, which means the use of e-commerce by farmers and entrepreneurial activities of farmers may present regional characteristics. Based on the aforementioned reasons, the sampling process can fairly reflect good representativeness at the national level. Taking into account the quality of the questionnaire, we conducted face-to face interviews with farmers to ensure that every respondent could better understand the questions, with each interview lasting about one hour. The questionnaire mainly investigated the basic situation of production and living of farmers in 2017. The questionnaire contents mainly included the farmers' basic information, household assets and income, internet utilization and e-commerce utilization. For entrepreneurial farmers, we investigated the operation and development conditions of their own entrepreneurship.

To identify the sample types accurately, we defined farmers' entrepreneurship as follows. Agricultural entrepreneurship refers to the expanding of the business scale in traditional agricultural industries, such as planting, breeding and fishing, or the application of new technologies, the launch of new business and the establishment of new organizations, such as family farms or farmers' professional cooperatives, to improve the original production and operation patterns. The determination of the scale of agricultural entrepreneurship not only refers to the local professional larger-scale households but also considers the actual situation of the surveyed areas. Non-agricultural entrepreneurship refers to the establishment enterprises in all economic domains except for agriculture. Farmers worked on processing, manufacturing and construction enterprises in the industrial field and engaged in non-agricultural economic activities in the field of the service industry, such as professional services for non-agricultural production, retail and wholesale, catering and accommodation, transportation and housekeeping, cultural entertainment, medical and health services and other services. In the actual investigation, we also made a supplementary judgement based on the situation of capital, labor, time and motivation in the farmers' production and operation. According to the above delineation, the whole samples were divided into two groups, one of which includes 831 entrepreneurial farmers and the other includes 1116 non-entrepreneurial farmers. We extracted the entrepreneurial farmer samples as the final research data.

### 3.2. Variables and Summary Statistics

#### 3.2.1. Dependent Variables

This study employed e-commerce utilization as the outcome variable and measured it covering two aspects, specifically online purchases and online sales. First, we asked the respondents "Are you using e-commerce via the internet for online purchases or sales in your entrepreneurship?". If they answered "yes", they were defined as applying e-commerce. In this study, a total of 348 entrepreneurial farmers reported the utilization of e-commerce, accounting for 41.88% of the total samples. We then asked "Are you using Yun Nong Chang, Rural Taobao, JD.com or other e-commerce platforms to purchase raw materials, machinery and other production materials?" to investigate their online purchases

utilization and asked “Are you using WeChat, QQ, websites or other e-commerce platforms to sell products?” to judge their online sales utilization. It could be concluded from the target groups that 195 and 295 entrepreneurial farmers use online purchases and online sales, occupying 23.47% and 35.50% of the samples, respectively, which is basically consistent with Li et al. [64].

### 3.2.2. Independent Variables

The core variable of formal credit participation in this study is whether entrepreneurial farmer *i* has received credit from rural financial institutions. In the questionnaire, we designed the question “Has your family applied for credit from rural financial institutions, such as rural credit cooperatives, commercial banks, postal savings banks and so on which are around your place of residence, in the last three years?” The answers were given on a scale consisting of: 1 = no; 2 = yes but abandoned the application later; 3 = yes but was refused by the institutions; 4 = yes and received a partial loan; 5 = yes and received the full loan. If entrepreneurial farmers responded 4 or 5, it indicated participation in formal credit. In contrast, 1, 2 and 3 indicated no participation. We defined this as a dummy variable, that is, formal credit participation = 1 and no formal credit participation = 0. Within the entire sample, 422 entrepreneurial farmers engage in formal credit participation, accounting for 50.78%, following the results of Ma et al. [65]. Another key variable is the entrepreneurial farmers’ actual amount of credit approved by and obtained from rural financial institutions, which is a continuous variable to examine the internet learning effect, asset allocation effect, labor allocation effect and income growth effect of formal credit on the e-commerce utilization of entrepreneurial farmers.

### 3.2.3. Control Variables and Mediating Variables

The variables presented in Table 1 include farmers and credit characteristics used in the selection model to estimate propensity scores. Mediating variables on internet learning, asset allocation, labor allocation and income growth were used to examine the mediation effect. Table 1 also reports the description of variable definitions and summary statistics of variables according to formal credit participation status. Gender, Cooperative, New agricultural business entity, Social network, Mobile payments and Fund demand variables were measured by dummy variables. Besides, the variables about Age, Education, Distance, Fixed asset, Working capital, Short-term and Long-term employment variables were measured by using actual measurement values. Gross and Net income variables were measured by adding 1 to the entrepreneurship income, and then taking the natural logarithm. Credit cognition, Institution support, Internet knowledge and Information access variables were measured by Likert scales, where means 1 is equal to strongly disagree and 5 is equal to strongly agree.

Table 1 also reports the definitions of variables and summary statistics accordingly separated based on the formal credit participation status. It reveals the differences between the credit group and non-credit group in terms of the farmers and credit characteristics and mediating variables. Significant differences can obviously be seen in e-commerce utilization between the credit group and the non-credit group, and e-commerce utilization of the credit group is higher than that of the non-credit group. Online purchases and online sales show the same trends. By comparison, the entrepreneurial group of farmers who use formal credit are younger, have a higher level of education and are more familiar with the business processes and policies related to formal credit; besides, they have a stronger tendency towards using mobile payments and have a greater demand of funds for their productive investment. As for the mediating variables, the differences between the credit group and the non-credit group are statistically significant and the level of the credit group is higher. In conclusion, the preliminary analysis shows that formal credit promotes the entrepreneurial farmers’ e-commerce utilization through the four channels noted above, but further testing is still needed to verify the proposed hypotheses.

**Table 1.** Descriptions and summary statistics of variables, by formal credit participation status.

Variables	Description	Credit Group (n = 422)	Non-Credit Group (n = 409)	Differences
E-commerce utilization	=1 if they use the internet to purchase raw materials or sell agricultural products; =0 otherwise	0.50 (0.50)	0.34 (0.47)	0.16 ***
Online purchases	=1 if they use the internet to purchase raw materials; =0 otherwise	0.29 (0.46)	0.18 (0.38)	0.11 ***
Online sales	=1 if they use the internet to sell products; =0 otherwise	0.41 (0.49)	0.29 (0.46)	0.12 ***
Gender	=1 if male; =0 if female	0.84 (0.37)	0.71 (0.45)	0.13 ***
Age	Farmers' age in years	43.25 (8.84)	45.68 (9.48)	-2.43 ***
Education	Farmers' education in years	9.19 (3.16)	8.67 (3.38)	0.52 ***
Cooperative	=1 if they joined a cooperative; =0 otherwise	0.46 (0.50)	0.27 (0.44)	0.19 ***
New agricultural business entity	=1 if recognized as a new agricultural business entity; =0 otherwise	0.56 (0.50)	0.39 (0.49)	0.17 ***
Social network	=1 if relatives or friends work in financial institutions; =0 otherwise	0.18 (0.39)	0.11 (0.32)	0.07 ***
Distance	Distance from home to financial institution (Unit: kilometer)	4.78 (3.53)	5.24 (3.77)	-0.46 *
Mobile payment	=1 if they use mobile payment; =0 otherwise	0.91 (0.28)	0.78 (0.42)	0.13 ***
Credit cognition	"I am very familiar with formal credit and related policies."	3.44 (1.52)	3.42 (1.59)	0.02
Fund demand	=1 if have fund demand; 0 = otherwise	0.78 (0.41)	0.58 (0.59)	0.20 ***
Institution support	"I think local financial institutions are highly motivated to handle loan business."	3.63 (1.00)	3.52 (1.06)	0.11
Internet knowledge	"I know a great deal about the internet."	2.92 (0.97)	2.41 (1.06)	0.51 ***
Information access	"I often get valuable information from smartphones and the internet."	2.52 (0.69)	2.29 (0.81)	0.23 ***
Fixed asset	The natural logarithm of investment in fixed assets within past three years	8.63 (5.47)	6.87 (5.61)	0.76 ***
Working capital	The natural logarithm of working capital annually	9.71 (4.05)	8.94 (4.28)	0.77 ***
Short-term employment	Number of short-term employees in 2017	14.34 (39.20)	8.85 (35.65)	5.49 ***
Long-term employment	Number of long-term employees in 2017	3.77 (25.99)	1.37 (6.14)	2.40 ***
Gross income	The natural logarithm of entrepreneurship gross income in 2017	11.84 (2.84)	10.82 (3.05)	1.02 ***
Net income	The natural logarithm of entrepreneurship net income in 2017	10.30 (3.47)	9.76 (3.26)	0.54 ***

Note:<sup>1</sup> \*\*\*, \* denote a statistical significance at the 1% and 10% level, respectively; <sup>2</sup> standard errors are report in the parentheses.

The descriptive statistics of all variables in this study are shown in Table A1 of Appendix A. Regarding the entrepreneurial farmers' characteristics, males account for 78%, their average age is 44 and the average years of education is 8.94 years, while 36% of entrepreneurial farmers have joined cooperatives and 48% belong to new agricultural business entities. This status quo is in line with current reality in rural China and roughly consistent with Yin et al. [30]. Regarding credit characteristics, the proportion of entrepreneurial farmers who have relatives or friends working in financial institutions is 15%, the average distance from home to financial institutions is 5.50 km and 85% of en-

entrepreneurial farmers use mobile payments. Entrepreneurial farmers have moderately positive credit perceptions and believe that financial institutions are generally motivated to handle business. A total of 69% of entrepreneurial farmers have fund demands. These results are approximately consistent with Wang and Kong [66]. As for mediation variables, the mean of entrepreneurial farmers' internet knowledge and access to internet information are 2.68 and 2.41, respectively. The average natural logarithm of the fixed asset investment within the past three years is 7.76, and the average natural logarithm of the annual working capital is 9.32. The average number of short-term and long-term employees hired by entrepreneurs is 11.65 and 2.59. The average natural logarithm of entrepreneurship gross and net income in 2017 are 11.37 and 11.05. These values are roughly consistent with Su and Kong [67] and Zhao et al. [29].

### 3.3. Model specification

#### 3.3.1. Propensity Score Matching

According to the random utility decision model [68], the difference between the utility of entrepreneurial farmer  $i$  when choosing to participate in formal credit ( $U_{1i}$ ) and when choosing not to participate in formal credit ( $U_{0i}$ ) is  $L_i^*$ . If  $L_i^* = U_{1i} - U_{0i} > 0$ , then the entrepreneurial farmer chooses to borrow formal credit from rural financial institutions. To investigate the formal credit participation of entrepreneurial farmers, we established the following regression equation:

$$L_i^* = \phi(Z) + \varepsilon_1 \tag{1}$$

$L_i^*$  is a latent variable; if  $L_i^* > 0$ , it means that entrepreneurial farmer  $i$  participates in the formal credit market; otherwise, he or she does not participate.  $Z$  denotes a series of exogenous explanatory variables, which are the characteristics of farmers' and credit.  $\varepsilon_1$  is a random disturbance term.

To measure the impact of formal credit on the e-commerce utilization of entrepreneurial farmers, we established the following equation:

$$D_{ki} = \alpha + \delta L_i + \phi(X) + \varepsilon_2 \tag{2}$$

$D_{ki}$  denotes the latent variables of entrepreneurial farmers' e-commerce utilization, and  $k = 1, 2, 3$  indicates e-commerce, online purchases and online sales utilization in turn. For example, if farmer  $i$  applies e-commerce, it is  $D_{1i} = 1$ ; otherwise,  $D_{1i} = 0$ .  $X$  are other explanatory variables that affect entrepreneurial farmers' e-commerce utilization.  $\alpha$  is a constant term and  $\varepsilon_2$  is a random disturbance term.

If entrepreneurial farmers are randomly assigned to the credit group and the non-credit group, then the parameter  $\delta$  can reflect the probability that formal credit affects entrepreneurial farmers' e-commerce utilization accurately. However, the formal credit participation choice  $L_i$  is affected by some unobservable factors possibly related to the outcome variables  $D_{ki}$ , leading to inexact estimation results due to the correlation between  $L_i$  and  $\varepsilon_2$  in Equation (2) [69]. In addition, credit participation causes selection bias because of entrepreneurial farmers' distinctive initial resource endowment. If the estimations do not consider the self-selection issue of entrepreneurial farmers in credit participation, the results  $\delta$  will still be biased. While several methods allow researchers to control self-selection bias and estimate treatment effects, data availability often limits the choice. In the absence of suitable panel data or credible instruments, propensity score matching (PSM) has emerged as a popular approach in agricultural economics contexts. In fact, PSM tries to make the observation data as close as possible to the random experimental data by matching the sample, which can reduce the deviation caused by the above problems. In this study, we applied PSM and estimated the average treatment effect of the treated (ATT) of formal credit participation on e-commerce utilization.

The estimation process of PSM was as follows. First, the entrepreneurial farmers were divided into a treatment group (participating in formal credit) and a control group (not participating in formal credit). For those farmers who participated in formal credit,

there was no observational data showing whether they would still choose to applicate e-commerce or not. If they had not participated in formal credit in reality, the second step was to construct a counterfactual framework by calculating propensity scores to infer the potential outcome under multiple characteristics. We estimated the propensity score  $p_i = P(L = 1|Z_i)$  for each entrepreneurial farmer  $i$  with a logit model. In this model, we included farmers characteristics, credit characteristics, internet learning, asset allocation and income growth variables in the propensity score matching method model to conduct more accurate matching. This model is equivalent to the formal credit participation model and is reported in Appendix A Table A2 (Equation (1)). Next, for each farmer participating formal credit, a credit non-participating farmer with a similar propensity score was matched, thereby constructing a statistical control group. The essence of this method was to create a random experiment condition, matching credit participating farmers with non-participating farmers in multidimensional covariates so that two farmers, after matching, have the same basic features in addition to credit participation. Within this counterfactual framework, the within-matched-pair difference in the outcome was then attributable to the credit's impact and the treatment effects were estimated by averaging the within-matched-pair differences in the outcome. Thus, we defined the average treatment effect on the treated (credit participation group) as follows:

$$\widehat{ATT} = \frac{1}{N_1} \sum_{i:L_i = 1} (D_i - \widehat{D}_{0i}). \quad (3)$$

In Equation (3),  $N_1$  represents the number of entrepreneurial farmers in the treatment group.  $\sum_{i:L_i = 1}$  indicates that only the farmers participating in formal credit are included.  $D_i$  is the e-commerce utilization of farmer  $i$ , and  $\widehat{D}_{0i}$  is the value of e-commerce utilization when a credit participating farmer does not participate in credit in the counterfactual context.

As is well known, the "best" matching method is up for debate because of the certain measurement deviation of different matching methods, as even with the same sample data, it will also produce heterogeneous measurement results. Also, there are no widely accepted guidebooks or literature about how to choose the best matching method to estimate the optimal results. However, most scholars use multiple matching methods to estimate the results [70,71]. If the results after estimation by using several matching methods are similar or even consistent, it means that the sample validity is reasonable and the estimators are robust [72,73].

For the sake of enhancing the reliability of the conclusions, we adopted six matching methods for calculation. The introduction to these methods was as follows. The first step was k nearest neighbor matching, that is, matching by looking for k individuals from different groups with the closest propensity score. In this study, k was set to 4; in other words, we performed one to four matching to minimize the mean square error. The second was caliper matching, performed by limiting the absolute distance of the propensity score. After calculation, this study set the caliper to 0.05 for matching. The third was nearest neighbor matching with a caliper, which is matching by finding the nearest k individual in different groups within the given caliper range. In this study, the caliper was set to 0.05 for one to four matching. The fourth was kernel matching whose function is used to compute the weight for matching. The matching uses the epan kernel, and the bandwidth is 0.06 by default. The fifth was spline matching, a smoother cubic spline that is used to evaluate the weight for matching. The sixth is Mahalanobis matching conducted by calculating the Mahalanobis distance of covariates to perform sampling with replacement and the k nearest neighbor. This study set k to be equal to 4. In addition, we also reported the arithmetic mean of the average treatment effect under the above matching methods for empirical analysis later.

The Stata 15.0 software was used to implement propensity score matching estimation. Firstly, the propensity score matching technique was updated in the Stata 15.0 software. Secondly, the data was imported into the software and organized. Then, we entered

different codes in the command window in terms of different propensity score matching methods. Finally, the result window generated the results of common support domain, balance test and treatment effect. In addition, we also reported the arithmetic mean of the average treatment effect under the above matching methods for empirical analysis later.

### 3.3.2. Mediation Analysis: Bootstrap Method

The impact of formal credit participation on the e-commerce utilization of entrepreneurial farmers may be realized through the four mediating channels in the previous analysis. Regarding the test methods of the mediation effect, many scholars have adopted causal step regression [74]. However, in recent years, many questions have arisen about the validity of the method and the rationality of the procedure. Based on this context, more and more scholars had chosen to use the bias corrected percentile bootstrap CI method (hereinafter called the “bootstrap method”), as proposed by Preacher and Hayes [75], to test the mediation effect. This method can obtain a more accurate confidence interval and higher test validity, and it is suitable for a variety of complex situations, including moderated mediation, mediated moderation, multiple categorical independent and binary dependent situations. We further built the following model to test the four mediating effects by using the bootstrap method.

$$Y = cX + e_1 \quad (4)$$

$$M = aX + e_2 \quad (5)$$

$$Y = c'X + bM + e_3 \quad (6)$$

In the above functions,  $X$  denotes the independent variable, which is the amount of formal credit,  $M$  denotes the mediating variables, which are four influencing channels and  $Y$  denotes the dependent variable, which is e-commerce utilization.

The mediation effect test was divided into three steps. The first step was to test the coefficient  $c$ , only when  $c$  is significant can proceed to the next step, otherwise stop the analysis. The second step was to test indirect effect  $ab$  by bootstrap method. If  $ab$  is significant, the mediating effect exists and its value is indirect effect  $ab$ , otherwise the mediating effect does not exist. The last step was to test coefficient  $c'$  that is also called the direct effect. If the direct effect  $c'$  is significant,  $M$  can be confirmed to have a partial mediating effect. If not,  $M$  have a full mediating effect.

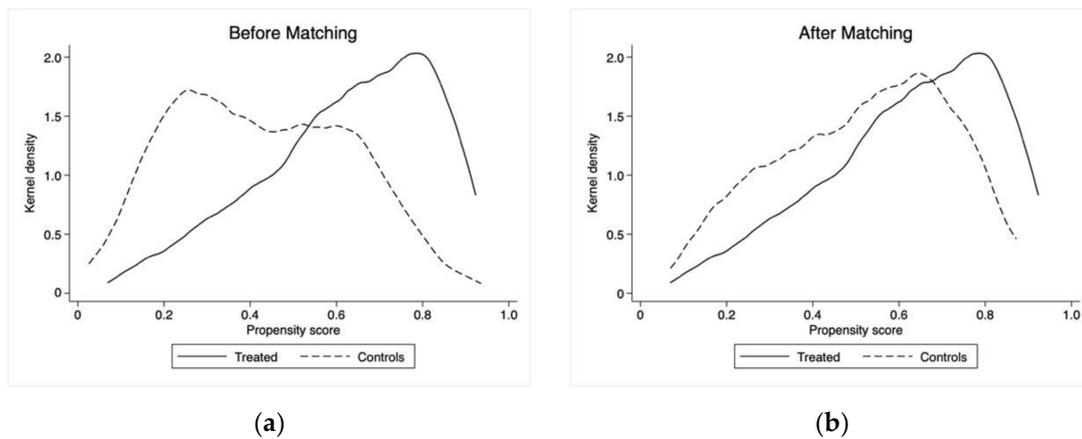
The Bootstrap method operations on software are as follows. Data are transferred to SPSS 22.0 for statistical analysis. By using the PROCESS plug-in, the bootstrap setting is conducted first, then model 4 is chosen, the “bootstrap samples” are set to 5000 and the “confidence level for confidence intervals” is set to 95%; these are all customary settings.

## 4. Results and Discussion

### 4.1. Common Support Domain and Balance Test

The PSM model specification must meet two preconditions: the overlap assumption and the balancing property [70]. For the overlap assumption, the common support domain needs to be tested to ensure a desirable sample matching. If the common support domain for entrepreneurial farmers who participate in formal credit and those who do not participate in formal credit is small, it will not be able to achieve an effective matching and will result in sample loss [76]. This study calculated the fitting value of the conditional probability  $P_i$  of farmer  $i$  participating in credit based on the estimated results of Equation (1), that is, farmer  $i$ 's propensity score. Then, density function graphs were drawn to check the common support domain to ensure the matching quality of the sample data [77] (see Figure 2). The propensity scores of the participating samples and the non-participating samples in formal credit have a large overlap, and the common support interval is [0.0698, 0.9229]. In addition, the treatment group loses 4 samples and the control group does not lose any sample according to the maximum loss results obtained by 6 different matching

methods. Compared with the total sample, the loss ratio is low, indicating a rational matching.



**Figure 2.** Propensity score distribution of rural credit participation before and after matching.

For the balancing property, the overall matching quality indicators are presented in Table 2. The results show that the standard deviation between the two groups after matching is reduced from 29.1 to 8.9% (less than 20%), and the overall biases are significantly corrected, which indicates that the matching quality is good enough. The likelihood ratio test shows that the joint significance test of covariates is statistically significant at the 1% level; however, the test value is no longer significant after matching. Besides, the pseudo-R<sup>2</sup> value is reduced from 0.155 before matching to 0.020 after matching. In conclusion, these results show that there are no significant differences between the credit group and the non-credit group, as suggested by Rosenbaum and Rubin [78]. The above test results reveal that those matching methods adopted in this study effectively balance the difference in the distribution of covariates between the treatment group and the control group, minimizing the sample selection bias problems.

**Table 2.** Test for overall matching quality by matching methods.

Method	Ps R <sup>2</sup>	LR Chi <sup>2</sup>	p > Chi <sup>2</sup>	MeanBias	MedBias
Unmatched	0.155	131.23	0.000	29.1	31.0
Nearest neighbor matching	0.020	18.49	0.359	6.5	6.0
Caliper matching	0.014	12.94	0.740	5.4	4.4
Nearest neighbor matching with caliper	0.019	16.75	0.472	6.1	4.4
Kernel matching	0.015	13.93	0.672	5.5	4.3
Spline matching	0.019	16.38	0.497	7.9	6.1
Mahalanobis matching	0.020	18.25	0.373	8.9	5.4

#### 4.2. Treatment Effect Estimation

The treatment effect of formal credit participation on the e-commerce utilization is reported in Table 3. The ATT measured by six matching methods all show a significant effect at the statistical level of 1% and have a positive sign. We calculated the arithmetic mean of the ATT with the six matching methods to represent the net effect. Indeed, the net effect is 0.1841, indicating that participation in formal credit will promote a significant increase of 18.41% of entrepreneurial farmers' e-commerce utilization after considering the selection bias, which is consistent with the current Chinese government policy. At present, China bolstering financial support for entrepreneurial farmers to develop e-commerce, the government promotes financial institutions to introduce multilevel and diversified financial support methods, focusing on relieving the loan impediments in e-commerce utilization for entrepreneurship farmers. Hypothesis H1 is thus verified. Although the financing channels

present a tendency of diversification [58], formal credit, as the key financing source, can relieve entrepreneurial farmers' capital stress effectively [24,79]. Therefore, entrepreneurial farmers can maintain their capital flow in the process of e-commerce utilization, which provides the conditions for entrepreneurial farmers to hire professional technical experts and equip themselves with digital devices, thus promoting their utilization of e-commerce.

**Table 3.** The effect of formal credit participation on e-commerce utilization.

Matching Method	Treated	Controls	ATT	S.E.	T-Stat
Nearest neighbor matching	0.5138	0.3267	0.1871 ***	0.0393	4.76
Caliper matching	0.5122	0.3216	0.1906 ***	0.0392	4.86
Nearest neighbor matching with caliper	0.5122	0.3265	0.1857 ***	0.0384	4.83
Kernel matching	0.5123	0.3334	0.1789 ***	0.0379	4.72
Spline matching	0.5138	0.3265	0.1873 ***	0.0387	4.83
Mahalanobis matching	0.5127	0.3376	0.1751 ***	0.0390	4.49
Average			0.1841		

Note: \*\*\* denote a statistical significance at the 1% level.

Tables 4 and 5 reveal the treatment effect of formal credit participation on online purchases and online sales, respectively. They indicate that formal credit participation has a positive impact on online purchases and online sales. ATT of online purchases measured by nearest neighbor matching and nearest neighbor matching with caliper methods are significant at 1% statistical level. The rest of the matching methods are significant at 5% statistical level. Averagely, formal credit participation increases the probability of entrepreneurial farmers' purchases online by 11.15%. As for ATT of online sales, it is significant at 5% statistical level by using nearest neighbor matching and caliper matching methods, furthermore, the rest of the matching methods are significant at 1% statistical level. On average, formal credit increases the probability of online sales by 14.69%. They all indicate that formal credit participation has a positive impact on online purchases and online sales. These results are basically consistent with Lin et al. [49] and Mei et al. [80]. Thus, hypothesis H1a, H1b are verified. When comparing online purchases and online sales, we find that the effect of formal credit promotes online sales more than online purchases. The findings indicate that formal credit alleviates entrepreneurial farmers' funding constraints when they plan to transform their entrepreneurial model by making online purchases and sales. Compared with the alleviation of funding constraints faced by entrepreneurial farmers in buying new varieties, technologies and equipment via the internet, credit has a better effect on easing the funding constraints of entrepreneurial farmers by extending product marketing channels and increasing the sales volume and market share through the internet.

**Table 4.** The effect of formal credit participation on online purchases utilization.

Matching Method	Treated	Controls	ATT	S.E.	T-Stat
Nearest neighbor matching	0.2883	0.1713	0.1170 ***	0.0416	2.81
Caliper matching	0.2892	0.1809	0.1083 **	0.0468	2.31
Nearest neighbor matching with caliper	0.2892	0.1718	0.1174 ***	0.0421	2.78
Kernel matching	0.2892	0.1803	0.1089 **	0.0459	2.37
Spline matching	0.2883	0.1806	0.1077 **	0.0457	2.35
Mahalanobis matching	0.2887	0.1792	0.1095 **	0.0459	2.39
Average			0.1115		

Note: \*\*\*, \*\* denote a statistical significance at 1%, 5% level, respectively.

**Table 5.** The effect of formal credit participation on online sales utilization.

Matching Method	Treated	Controls	ATT	S.E.	T-Stat
Nearest neighbor matching	0.4202	0.2762	0.1440 **	0.0575	2.50
Caliper matching	0.4215	0.2769	0.1446 **	0.0571	2.53
Nearest neighbor matching with caliper	0.4218	0.2810	0.1408 ***	0.0538	2.62
Kernel matching	0.4213	0.2649	0.1564 ***	0.0523	2.99
Spline matching	0.4201	0.2775	0.1426 ***	0.0549	2.60
Mahalanobis matching	0.4221	0.2694	0.1527 ***	0.0569	2.69
Average			0.1469		

Note: \*\*\*, \*\* denote a statistical significance at 1%, 5% level, respectively.

### 4.3. Heterogeneity Analysis

The heterogeneity analysis is reported in Table 6. We assume that, regarding the decision maker on formal credit participation, younger entrepreneurial farmers are more likely to apply e-commerce; thus, the utilization of e-commerce may have heterogeneous effects among age cohorts. We divide the whole sample into three subsamples: entrepreneurial farmers aged 19~39, 40~54 and above 55. From the age column in Table 6, we find that the e-commerce utilization treatment effect is significant for farmers aged 19~39 and for those aged 40~54 who participate in formal credit. However, the online purchases treatment effect is also significant for farmers aged 19~39 and 40~54. Online sales treatment effect for all ages is not significant. This indicates that younger farmers are more likely to be interested in accepting new business challenges [81]. Stronger work ability enables younger farmers to expand their entrepreneurial scale and increase their profits through emerging technologies such as the internet [82]. Compared with young farmers, old farmers who are physically incapacitated may be more likely to exit entrepreneurial activities.

**Table 6.** The heterogeneity analysis involving the effect of credit on e-commerce utilization.

Variables	Standard	E-Commerce			Online Purchases			Online Sales		
		ATT	S.E.	T-Stat	ATT	S.E.	T-stat	ATT	S.E.	T-Stat
Age	[19,39)	0.1399 *	0.0796	1.76	0.1765 **	0.0744	2.37	0.0992	0.0808	1.23
	[40,54)	0.1217 **	0.0507	2.40	0.0830 *	0.0437	1.90	0.0595	0.0635	0.94
	[55,69)	0.0268	0.1258	0.21	0.0362	0.0780	0.47	0.0207	0.0917	0.23
New agricultural business entity	Yes	0.2175 ***	0.0585	3.72	0.1358 ***	0.0521	2.60	0.1938 ***	0.0575	3.37
	No	0.0606	0.0675	0.09	0.0492	0.0575	0.86	0.0855	0.0531	1.61
Mobile payment	Yes	0.1522 ***	0.0441	3.45	0.0944 **	0.0394	2.40	0.1106 **	0.0435	2.54
	No	0.0875	0.0773	1.13	0.0090	0.0410	0.22	0.0375	0.0611	0.61

Note: \*\*\*, \*\*, \* denote a statistical significance at the 1%, 5% and 10% level, respectively.

Table 6 shows the heterogeneity results of new agricultural business entities. The treatment effects of formal credit promoting e-commerce utilization is statistically significant in the group of new agricultural business entities, including online purchases and online sales. However, for entrepreneurial farmers who do not have a new agricultural business entity, the results are not significant. These results reveal that formal credit has significantly promoted e-commerce utilization for entrepreneurial farmers, who are identified as a new agricultural business entity. In this study, the new agricultural business entities mainly include large-scale farming households, family farms, professional cooperatives and leading agricultural enterprises [83]. New agricultural business entities are beneficial in promoting the specialization, intensification and standardization of agricultural production and management activities [84]. E-commerce has also become a new choice for new agricultural business entities. However, the construction of new agricultural business entities is still

in the primary stage, and the main barrier that they face in their development is funding constraints. Hence, when obtaining formal credit support for developing new entities, these farmers are more inclined to use e-commerce than general farmers.

In addition, the results in Table 6 indicate that the effect of formal credit on e-commerce utilization is more significant for entrepreneurial farmers who use mobile payment. Mobile payment can be applied not only in the traditional agricultural business environment, but also in the field of mobile e-commerce [30]. It has become the important driving force of agricultural e-commerce development in recent years [85]. As an emerging and convenient sort of payment, mobile payment has the unique advantages of “mobility”, which can liberate entrepreneurial farmers from the constraints of time and space without using cash [86,87]. It is convenient for entrepreneurial farmers to handle their bank loans business. This is because it facilitates the handling entrepreneurial farmers’ bank loans business, while providing conditions for purchasing materials and selling agricultural products via e-commerce platforms.

4.4. Mechanism Test Analysis

We concentrate on the impact channels about how formal credit affects e-commerce utilization. According to the theoretical framework constructed above, we infer that formal credit can affect e-commerce utilization through four channels, namely internet learning, asset allocation, labor allocation and income growth, respectively. The mediation effects of the four channels are explored by using the bootstrap method. In fact, it is better to measure mediating channels by changes from before the credit granting to after the credit is granted. However, due to being limited by data, we use the levels values of the mediating variables at a later date in the bootstrap method. We assume that the mediating variables do not vary significantly between treated and non-treated samples so as to get more accurate estimation results. Besides, the actual amount of formal credit is an independent variable. The amount is 0 when entrepreneurial farmers do not participate in formal credit. If the mediating test results are significant and have a positive sign, it means that the enhancement of formal credit amount has promoted the e-commerce utilization by entrepreneurial farmers through mediating channels. As Table 7 shows, it is clear that all the direct effects’ p-values are below 5%, which demonstrates a significant impact of formal credit on e-commerce utilization after controlling the mediating variables of the four channels, and shows that it is necessary to use the partial mediation effect for further analysis.

Table 7. The mechanism of how formal credit affects e-commerce utilization.

Channel	Variables	Direct Effect	p Value	Indirect Effect	LLCI	ULCI
Internet learning effect	Internet knowledge	0.0382	0.0234	0.0114	0.0045	0.0213
	Information access	0.0364	0.0096	0.0032	-0.0027	0.0104
Asset allocation effect	Fixed asset	0.0334	0.0154	0.0032	0.0005	0.0082
	Working capital	0.0312	0.0250	0.0065	0.0021	0.0133
Labor allocation effect	Short-term employment	0.0038	0.0148	0.0016	-0.0016	0.0066
	Long-term employment	0.0315	0.0233	0.0105	0.0014	0.0452
Income growth effect	Gross income	0.0401	0.0160	0.0077	0.0022	0.0178
	Net income	0.0420	0.0111	0.0059	0.0015	0.0133

In the context of the internet learning effect, internet knowledge (indirect effect = 0.0114, LLCI = 0.0045, ULCI = 0.0213) shows an obvious mediation effect because the confidence interval between LLCI and ULCI does not contain 0 [75]. It indicates that the higher the credit amount that is approved, the more helpful it will be for entrepreneurial farmers to gain internet knowledge. However, information access (indirect effect = 0.0096, LLCI = -0.0027, ULCI = 0.0104) is not expressive in the mediation effect, since 0 is included in the confidence interval. The fixed assets (indirect effect = 0.0032, LLCI = 0.0005, ULCI = 0.0082) and working capital (indirect effect = 0.0065, LLCI = 0.0021, ULCI = 0.0133) both have a significant

mediation effect, indicating that the higher amount of approved credit, the more conducive it is to alleviating the liquidity constraints of entrepreneurial farmers. Meanwhile, it is also helpful for increasing internet device asset investment and improving the holding of working capital. Regarding the labor allocation effect, short-term employment (indirect effect = 0.0016, LLCI = -0.0016, ULCI = 0.0066) has no significant effect while long-term employment (indirect effect = 0.0105, LLCI = 0.0014, ULCI = 0.0452) is significant, part of the reason for this is the limitation of the time of approved credit, making it difficult for entrepreneurial farmers to pay daily salaries for temporary labors. Farmers' annual entrepreneurial gross income (indirect effect = 0.0077, LLCI = 0.0022, ULCI = 0.0178) and net income (indirect effect = 0.0059, LLCI = 0.0015, ULCI = 0.0133) have a significant mediation effect in the analysis of income growth channel. The results may imply that the more money is approved for formal credit, the faster accumulation of farmers' entrepreneurial wealth will be. Thus, hypotheses H2a, H2b, H2c and H2d are verified.

## 5. Conclusions and Policy Implications

Against the background of the strategy of widespread entrepreneurship, the transformation of farmers' entrepreneurship is important for stimulating the development of the rural entrepreneurial economy, deepening the industry convergence and accelerating the rural revitalization of China. The in-depth advancement of rural informatization has improved farmers' access to internet resources and utilization capabilities, providing conducive conditions for farmers to use e-commerce. Early studies focus on the influencing factors affecting farmers' e-commerce utilization, such as infrastructure, resource endowment, social network and cognitive factors [49]. However, funding constraints remain the key factor for upgrading farmers' entrepreneurship in the current and future periods. Some studies have found that credit constraints from financial institutes limit the investments of farmers' entrepreneurship [88]. Therefore, entrepreneurial farmers' formal credit and e-commerce utilization have attracted considerable attention. This study used survey data from 831 entrepreneurial farmers to analyze the impact of formal credit participation on e-commerce utilization empirically. Subsequently, it examined the heterogeneities and the mechanisms, and some interesting results were found in the end.

We used PSM with six matching methods to investigate the treatment effect of formal credit on e-commerce utilization. The significant findings reveal that entrepreneurial farmers' formal credit participation has promoted e-commerce utilization by 18.41%, while the net effect of formal credit on online purchases and online sales are 11.15% and 14.69%, respectively. The results are consistent with relevant research [58]. The main findings provide policy makers with adequate evidence that formal financial institutions in rural areas should increase lending opportunities and provide prudent financial support for farmers' entrepreneurial transformation. An important item on the agenda is advancing the development of financial institutions and alleviating the credit constraints on rural entrepreneurship. Financial institutions can also optimize the supply of rural credit products and services by building a click-and-mortar model. Additionally, it is important to actively guide and encourage farmers to experience diversified internet functions, such as online purchases and sales. The government should actively identify the pioneers, support and cultivate them vigorously, and let more entrepreneurial farmers participate in e-commerce. Meanwhile, entrepreneurial farmers should build strong ties with financial institutions, relatives, friends and fellow entrepreneurs to effectively configure available resources to overcome credit constraints.

Our study further indicates that the effect of formal credit on e-commerce utilization is more significant for younger entrepreneurial farmers, new agricultural business entities and mobile payment users. To encourage entrepreneurial transformation, policy makers could use these results to design targeted policies aiming for younger entrepreneurial farmers and large-scale entrepreneurship. Policies based on our findings could give these farmers the incentives to exploiting e-commerce advantages with the help of internet. Entrepreneurial farmers, especially for startups, must adapt to the development of the

digital economy and engage in e-commerce. It is urgent for formal financial institutions to establish a multilevel service system of heterogeneous farmers, highlighting the group of younger entrepreneurial farmers with smartphones as the potential customers. As for new agricultural business entities, on the one hand, entrepreneurial subsidies for them could be encouraged; on the other hand, the entry thresholds for applying formal credit should be appropriately relaxed. The more important issue is that entrepreneurial farmers should choose suitable development strategies according to the characteristics of their own entrepreneurship. In addition, younger and large-scale entrepreneurial farmers are suggested to focus on digital technology in entrepreneurial activities.

Finally, we used the bootstrap method to explore whether the influencing mechanisms concerning the amount of formal credit affect e-commerce utilization. The study found that there are four channels, which show partial mediation effects except for information access capabilities through smartphones and short-term labor employment, including improving internet knowledge (the internet learning effect), increasing fixed asset investment and annual cash holdings (the asset allocation effect), promoting long-term labor employment (the labor allocation effect) and raising the entrepreneurial gross income and net income (the income growth effect). To enhance the sustainability and resilience of farmers' entrepreneurship, policy makers can enact measures through the allocation effect of essential productive factors and income growth, fully considering the impact of credit on the internet, labor, land and capital. By strengthening the mechanism design for balanced development and coordinating the rational and orderly flow of rural internet use, capital and labor, it can fully activate rural entrepreneurial farmers' utilization of e-commerce and deliver new energy for rural entrepreneurial transformation. Entrepreneurial farmers should participate in theory course and learning skills training to learn digital entrepreneurship management knowledge. Measures should be taken for entrepreneurial farmers to constantly strengthen the commercial management of capital and employment to help the sustainable and sound development of entrepreneurship.

This study is helpful for understanding the effect of formal credit on e-commerce utilization of entrepreneurial farmers and its mediating mechanism. However, limitations still exist in this study, which point out several directions for future research at the same time. First, sample data were collected from Shaanxi province, Ningxia province and Shandong province; though we used a stratified random sampling method to choose representative sample, entrepreneurial farmers' formal credit participation and e-commerce utilization behavior may be different in other provinces. To generalize our findings, future research could collect survey data from other provinces. Second, we analyzed the mediating mechanism between formal credit and e-commerce utilization. Due to data limitations, the measurement of mediating variables cannot be done by changes in level from before the credit granting to after the credit was granted. Hence, future research should consider using panel data through continuously tracking. Third, limited control variables were added to the PSM model to explore the nexus between formal credit and e-commerce utilization. Some variables such as participation willingness, government action and entrepreneurial stage were not considered in this paper. In the future, more proper variables and different methods can be taken into account to ameliorate and extend the present study.

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**Conflicts of Interest:** The authors declare no conflict of interest.

### Appendix A

**Table A1.** Summary statistics of variables.

Variables	Mean	Median	Std	Min	Max
E-commerce utilization	0.42	0	0.49	0	1.00
Online purchases	0.23	0	0.42	0	1.00
Online sales	0.35	0	0.48	0	1.00
Formal credit participation	0.51	1.00	0.50	0	1.00
Gender	0.78	1.00	0.42	0	1.00
Age	44.45	46.00	9.23	19.00	69.00
Education	8.94	9.00	3.28	0	16.00
Cooperative	0.36	0	0.48	0	1.00
New agricultural business entity	0.48	0	0.50	0	1.00
Social Network	0.15	0	0.35	0	1.00
Distance	5.50	3.50	3.66	0	17.50
Mobile payment	0.85	1.00	0.36	0	1.00
Credit cognition	3.43	4.00	1.55	1.00	5.00
Fund demand	0.69	1.00	0.46	0	1.00
Institution support	3.57	4.00	1.03	1.00	5.00
Internet knowledge	2.68	3.00	1.04	1.00	5.00
Information access	2.41	3.00	0.76	1.00	5.00
Fixed asset	7.76	10.31	5.60	0	17.91
Working capital	9.32	10.60	4.18	0	16.30
Short-term employment	11.65	1.00	37.58	0	500
Long-term employment	2.59	0	19.07	0	50
Gross income	11.37	11.70	2.98	0	18.42
Net income	10.05	10.82	3.38	0	16.12
Observations			831		

**Table A2.** Estimation of formal credit participation decision model (logit regressions).

Covariate	Coefficient	Marginal Effect
Gender	0.4472 *** (0.1342)	0.0892 *** (0.0269)
Age	-0.0169 ** (0.0074)	-0.0033 ** (0.0015)
Education	-0.0412 (0.0299)	-0.0082 (0.0059)
Cooperative	0.5188 ** (0.2032)	0.1035 *** (0.0399)
New agricultural business entity	0.4434 ** (0.2015)	0.0885 ** (0.0399)
Social network	0.0769 * (0.0463)	0.0154 * (0.0092)
Distance	-0.0597 ** (0.0267)	-0.0119 ** (0.0053)
Mobile payment	0.7005 ** (0.3094)	0.1398 ** (0.0610)

Table A2. cont.

Covariate	Coefficient	Marginal Effect
Credit cognition	0.2880 *** (0.0698)	0.0575 *** (0.0133)
Fund demand	0.9117 *** (0.2371)	0.1819 *** (0.0448)
Institution support	0.1232 * (0.0742)	0.0248 * (0.0148)
Internet knowledge	0.2677 ** (0.1132)	0.0534 ** (0.0223)
Information access	0.1028 (0.1374)	0.0205 (0.0274)
Fixed asset	0.0400 ** (0.0171)	0.0080 ** (0.0034)
Working capital	0.1991 *** (0.0741)	0.0039 *** (0.0014)
Gross income	0.0702 (0.0511)	0.0140 (0.0101)
Net income	0.0934 ** (0.0436)	0.0186 ** (0.0087)
Pseudo R <sup>2</sup>		0.1552
Wald chi <sup>2</sup>		103.65 ***
Log pseudolikelihood		−357.2713
Observations		831

Note: <sup>1</sup> \*\*\*, \*\*, \* denote a statistical significance at 1%, 5%, 10% level, respectively; <sup>2</sup> standard errors are report in the parentheses.

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