Empirical Analysis on the Impact of Poverty Alleviation by Rural E-commerce on Farmers' Income

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

ABSTRACT

According to the data of 200 valid questionnaires collected in 11 poor villages of 7 townships, 5 counties in Zhumadian region, this paper use the Difference-in-differences(DID) model to calculate the change difference of the per capita net income, per capita agricultural operating net income, and per capita non-agricultural net income between the farmers who have participated or so. After that, this paper used the fixed effect model to analyze the effect of other control variables on the farmers' income. The research results are as follows: The rural E-commerce poverty alleviation policy has a significant positive impact on per capita net income, per capita net agricultural operating income, and per capita non-agricultural net income of farmers, and the income structure of the farmers' family can be changedin the short term through poverty alleviation.

Keywords:Poverty Alleviation;Rural E-commerce Poverty Alleviation; Farmer Income; DID Model

1. INTRODUCTION

In November 2016, the State Council Poverty Alleviation Office, together with the National Development and Reform Commission, the Central Network Information Office, the Ministry of Commerce and other national ministries and commissions in China jointly issued the "Guiding Opinions on Promoting Accurate Poverty Alleviation for E-commerce", which first proposed the guiding ideology and overall objectives, basic principles, main tasks and safeguards, etc., of rural e-commerce poverty alleviation. The top-level design for rural e-commerce poverty alleviation has initially been completed. Since then, relevant ministries and commissions of the State Council of the People's Republic of China have successively issued a large number of supporting policy documents, fully supporting poor rural areas to formulate medium and long term plans and implementation rules for rural e-commerce poverty alleviation according to their actual conditions. Under this background, the Zhumadian area in Henan Province vigorously promotes the rural e-commerce precision

poverty alleviation project, and strives to solve the problems of restricting the development of e-commerce in poor counties and poor villages and the implementation of rural e-commerce poverty alleviation projects, and promotes characteristic industries and rural e-commerce to integrated development in poor counties and poor villages. It is benefit to transform the advantages and resources of poverty-stricken counties and poverty-stricken villages into incomes of farmers, and help more poor farmers to participate in various ways such as e-commerce, offline employment, online sales, land transfer, and share-based dividends. The local e-commerce poverty alleviation activities expand the income sources of poor households, and steadily increase household income levels. Therefore, the studying of the rural e-commerce poverty alleviation has significance for the implementation of e-commerce poverty alleviation in other regions.

2. RURAL E-COMMERCE POVERTY ALLEVIATION

In December 1984, the World Telecommunication Development Independent Commission issued The Missing Link, also known as the Maitland Report or the Report of the Maitland Commission, clearly stating to strengthen the infrastructure construction of information and communication technologies(ICT) in developing countries[1], improving communication conditions for urban and rural residents, expanding information communication and exchanges, driving the country's economic take-off and development, and reducing the size of the poor. This report is the earliest research literature on the field of information poverty alleviation. It has pioneered the use of ICTs to reduce poverty in developing countries. It provides the most primitive theoretical guidance for developing countries to carry out information poverty alleviation in the practice.

At present, scholars have carried out theoretical and practical discussions on information poverty alleviation, rural e-commerce, and rural e-commerce poverty alleviation. Charles Kenny argues that information and communication technology (ICT) is a powerful tool for empowering and increasing income in developing countries [2]. It also points out that broadcasting and telephone are the most suitable communication tools for the poor, and the government should concentrate on opening private and community broadcasts. Expand the use of telephone services to effectively play the positive role of information and communication technologies in promoting poverty alleviation and poverty alleviation in poor areas. Adeniji [3] studied how information and communication technologies can improve the utility of small producers in Nigeria, pointed out that the advantages and potential of information and communication technologies are in enhancing food security and alleviating poverty. Burga and Barreto [4], Shimamoto et al, [5] found that the widespread use of the Internet and mobile phones have a significant positive effect to understanding market information for farmers, increase agricultural product sales prices, increase agricultural product sales, and increase rural employment and improvement of production and living conditions based on rural survey data from Peru and Cambodia. Nora Abdalla Hassan Basher [6] pointed out in the study of poverty in Sudan that information and communication technologies have an important impact on people's awareness, education, health, employment, environment, social equity, agriculture and grazing. The government should formulate the correct investment, resource policies and rules and regulations to create a good development environment, promote the progress of information and communication technology in poverty-stricken areas, and benefit its economic and social development and poverty improvement.

ZhengWensheng et al. [7] believed that rural e-commerce has potential economic advantages, such as online cooperation could bring opportunities with low input and high output effects, reduce information asymmetry of farmers, reduce transaction costs, and achieve effective resource allocation through transaction monitoring, reduce market risks

and so on. Based on the field research of Shaji Town in Jiangsu Province, Wang Xiangdong [8] believed that poor farmers could use the Internet and third-party e-commerce trading platforms to create online stores, directly connect to the online consumer market, master order rights and pricing power, and get rid of information weakness, and engage in online sales of offline industries, achieve stable employment, obtain wage income, raise household income levels, and then achieve income increase and poverty decrease .The farmers' C2C direct sales (ie, farmer's online shop) were simple, fast and easy-to-follow new ways for farmers to sell. The rich product categories, perfect brands, flexible promotion methods and effective rights protection were continuing to expand the sales of store products and the increase of farmers' income.

Zhu Jiarui et al. [9] conducted a comprehensive and in-depth analysis of the unique characteristics, construction principles and processes of rural e-commerce poverty alleviation model, and believed that the role of poverty alleviation in promoting rural e-commerce poverty alleviation was directly related to e-commerce rural poor poverty alleviation. According to the different roles of poverty alleviation, the rural e-commerce poverty alleviation models were defined the public institution-led model, the agricultural enterprise-led model and the professional cooperative-led model. The advantages and disadvantages of these three models were further analyzed. On this basis, Zhang Yan et al. [10] and MengBaocheng et al. [11] further defined the rural e-commerce poverty alleviation models of an individual business model, a cooperative operating model, an enterprise-driven poverty alleviation model, a public institution-led model, and commissioned professional operators model.

Ma Zebo [12] based on the questionnaire survey of 630 farmers in the frontier ethnic areas, from the perspective of farmer endowment and regional environment, analyzed the willingness of farmers to participate in rural e-commerce poverty alleviation and its influencing factors. The results showed that the higher the education level, the stronger the willingness of participation; the lower the household income level, the greater the probability of participation. The perfect e-commerce logistics system, the moderate scale of agriculture, the high degree of standardization of agricultural products, and the government's vigorous promotion could help to encourage farmers to participate in rural e-commerce poverty alleviation activities. The farmers' low awareness of rural e-commerce, the lag of e-commerce infrastructure construction in poverty-stricken areas, the lack of rural e-commerce service system, and the limited scale of agricultural production and management were four major obstacles affecting farmers' willingness to participate in rural e-commerce poverty alleviation [13].

China is witnessing the following development in Information and Communication Technology (ICT) application in rural areas: Internet infrastructure is strengthened; E-commerce in rural areas is thriving; rural information service is upgraded; A solid progress has been made in Agricultural Internet of Things and rapid deployment of big-data technology[14].

Poverty reduction involves both balanced development and human rights protection. There are many ways to reduce poverty, and the use of financial instruments in poverty reduction is a universal tool and method throughout the world [15]. In order to ensure the realization of the general goal of poverty reduction,it is necessary to make overall plans for e-commerce poverty reduction, lay a solid foundation for targeted poverty reduction industries, give full play to the leading role of talents and technologies, strengthen infrastructure construction,

promote e-commerce in poverty alleviation, and improve the accuracy of targeted poverty reduction[16].

In summary, in actual operation, e-commerce poverty alleviation has not yet played an effective role in precision poverty alleviation because it still faces some problems. Mainly reflected in the weak foundation of e-commerce poverty alleviation industry, insufficient innovation ability and the corresponding public services are not in place. And there are few positive papers on poverty alleviation policy by use of DID model. Therefore, our research has contributed to solving the problems.

3. THE THEORETICAL MODEL

The dual difference model, also known as the Difference-In-Difference Model (DID model), is a quantitative analysis method that evaluates the net impact of a policy, a project, or a behavior on the target. A DID model for evaluating the impact of rural e-commerce poverty alleviation on farmers' income is

$$Y = \alpha + \beta T + \lambda P + \theta TP + \varepsilon \quad (1)$$

Y is the dependent variable, indicating the per capita net income of the farmers. And P is a dummy variable, indicating whether the affected households participate in the rural e-commerce poverty alleviation, that is, participation means P=1, no participation means P=0. T is a dummy variable, indicating that the affected farmers participate in rural e-commerce poverty alleviation, that is, T=0 means before participation and T=1 means after participation. ε is a random disturbance item, which represents other un-measurable factors affecting the income of farmers.

For the treatment group farmers, P=1, the DID model can be simplified as: Y=α+βT+λ+θT+ε. Then, the incomes of the treatment group farmers before and after the participation are

$$Y = \begin{cases} \alpha + \lambda + \varepsilon, T = 0 \\ \alpha + \beta + \lambda + \theta + \varepsilon, T = 1 \end{cases} \quad (2)$$

Furthermore, the average change in per capita income of the treatment group before and after the implementation of rural e-commerce poverty alleviation is

$$\mathrm{Diff_A} = (\alpha + \beta + \lambda + \theta + \varepsilon) - (\alpha + \lambda + \varepsilon) = \beta + \theta \quad (3)$$

For natural group farmers, P=0, the DID model can be simplified to $Y = \alpha + \beta T + \varepsilon_{\circ}$ Then, the income of the natural group farmers before and after the implementation is:

$$Y = \begin{cases} \alpha + \varepsilon, T = 0 \\ \alpha + \beta + \varepsilon, T = 1 \end{cases} \quad (4)$$

Furthermore, the average change in per capita incomes of the natural group farmers before and after the implementation of rural e-commerce poverty alleviation is

$$\mathrm{Diff_B} = (\alpha + \beta + \varepsilon) - (\alpha + \varepsilon) = \beta \quad (5)$$

Therefore, the net effect (net impact) of rural e-commerce poverty alleviation on the income of participating farmers is

$$\mathrm{Diff} = \mathrm{Diff_A} - \mathrm{Diff_B} = (\beta + \theta) - \beta = \theta \quad (6)$$

That is, the parameter of WP in the model is a double difference estimation value, which represents the net effect or net effect of rural e-commerce poverty alleviation on farmers' income, and also represents the policy effect of rural e-commerce poverty alleviation.

4. DATA SOURCE AND STATISTICAL DESCRIPTION OF THE BASIC CHARACTERISTICS OF THE FARMERS INTERVIEWED

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn.

4.1 The distribution of Data

The data used in this paper was from the household survey in Zhumadian area, where 214 questionnaires were completed, 14 unqualified questionnaires were removed, and the remaining 200 questionnaires were valid, in which farmers of 136 questionnaires participated in e-commerce poverty alleviation, accounting for 68%. There were farmers of 64 questionnaires not participating, accounting for 32%. In addition, 84 of the 200 households surveyed were poor households, accounting for 42%. 116 households were out of poverty, accounting for 58%. The specific distribution of the interviewed farmers is shown in Table 1.

Table 1. Distribution of the interviewed farmers

Distribution	Zhuantan township	Erlangtownship	Tandian town	Yushan town	Wagang town	Shaodian township	Liupen town
Participating farmers	31	16	25	37	27	0	0
Not-Participating farmers	13	4	8	11	9	14	5
total	44	20	33	48	36	14	5
The proportion	22%	20%	16.5%	24%	18%	7%	2.5%

In the Zhumadian area, the implementation of rural e-commerce poverty alleviation was relatively late. Since 2016, the support policies for promoting the implementation of the rural e-commerce poverty alleviation project have been intensively released. The poverty-stricken counties, poverty-stricken townships and poor villages have been encouraged and supported to implement rural e-commerce poverty alleviation, which initially achieved significant poverty alleviation results. In addition, according to the actual situation of pre-investigation in Songji Village in Xiping County in Zhumadian in early 2018, and the availability and accuracy of farmers' income data, the time of year before the participation of rural e-commerce poverty alleviation was selected in 2015, the time of year after participation of rural e-commerce poverty alleviation was selected in 2017. It could accurately measure the direction and influence degree of rural e-commerce poverty alleviation on farmers' income.

4.2 Statistical description of the characteristics of the farmers interviewed

The basic characteristics of the farmers mainly include age, gender, whether or not the head of household, education level, total family population, non-agricultural labor ratio, and family cultivated area. The statistical description of the characteristics of the interviewed farmers is shown in Table 2.

Table 2. Statistical description of the characteristics of the interviewed farmers

Variable	Minimum	Maximum	Mean	Standard Deviation
Age	1	5	3.38	1.03
Gender	0	1	0.57	-
Whether or not the head of household	0	1	0.58	-
Education level	1	4	2.04	0.73
Total family population	1	11	3.62	1.68
Non-agricultural labor ratio	0	1	0.57	-
Family cultivated area	1	14	4	1.8

Note: The classification of age of the interviewed farmer: 1.39 years old and below, 2.40-49 years old, 3.50-59, 4.60-69, 5.70 years old and above; gender: male 1, female 0; whether or not the head of household: yes 1, no 0; educated level: 1. Not attended, 2. Elementary school, 3. Junior high school, 4. High school, 5. College and above.

Table 3. Gender of the interviewed farmers and the distribution of "whether or not the head of household"

Variable	the number of people	proportion (%)
Male	113	56.5%
Female	87	43.5%
Head of household	115	57.5%
Non-head of household	85	42.5%

Table 4. Age of the interviewed farmers

Age	39 years old and below	4 40-49 years old	50-59 years old	60-69 years old	70 years old and above
Number of people	9	32	58	77	24
Proportion (%)	4.5%	16%	29%	38.5%	12%

Table 5. Education level of the interviewed farmers

Education level	Not attended	Elementary school	Junior high school	High school	College and above
Number of people	44	111	42	3	0
Proportion (%)	22%	55.5%	21%	1.5%	0

It can be seen from the above table that the proportion of males and females in the surveyed households was 56.5% and 43.5% respectively, of which the proportion of household heads was 57.5%, the youngest was under 39 years old, the maximum age was over 70 years old, and the average age was 50-59. The number of interviewed households between the ages of 40 and 69 accounted for 83.5%, indicating that the survey covered all age levels, and

could reflect the implementation of the poverty alleviation. The level of education of the interviewed farmers was generally low. The number of rural households who had not attended school and only attended primary school was 155, accounting for 77.5%, which was generally in line with the current rural population. The number of people was between 1 and 11, and the average number per household was 3-4.The average and standard deviation of non-agricultural labor ratio were 0.57 and 0.49 respectively, indicating that most of farmers in the survey area were more willing to go out or work locally in order to obtain higher wage income than agricultural income.The average cultivated land area of the interviewed households was 4 Mu.

4.3Satisfaction of the interviewed farmers participating in rural e-commerce poverty alleviation

According to Table 6, nearly 69.1% of the respondents indicated that they were very satisfied or satisfied with regard to raising the income level. In terms of the improvement of family living standards, 52.9% of the respondents indicated that they were very satisfied or satisfied. It can be seen that in the process of implementation, rural e-commerce poverty alleviation could indeed enrich the sources of income, optimize the income structure, increase household income, and at the same time significantly increase expenditures and improve living standards. In terms of overall satisfaction, 61.8% of the surveyed households expressed satisfied or very satisfied, and only 11.8% of the surveyed households expressed dissatisfied or very dissatisfied.

Table 6. Satisfaction of the interviewed farmers in rural e-commerce poverty alleviation (%)

Item	very satisfied	satisfied	generally	dissatisfied	very dissatisfied
Raising the income level	3.7%	65.4%	22.8%	7.4%	0.7%
The improvement of family living standards	1.5%	51.4%	28.7%	13.2%	5.2%
Satisfaction	2.2%	59.6%	26.5%	10.3%	1.5%

5. AN EMPIRICAL ANALYSIS OF THE IMPACT OF RURAL E-COMMERCE POVERTY ALLEVIATION ON FARMERS' INCOME

5.1 An Empirical Analysis of the Impact of Single Variable of E-commerce Poverty Alleviation on Farmers' Income

5.1.1 Variable selection and descriptive statistics

In this paper, the impact of rural e-commerce poverty alleviation on the income of farmers was studied. The changes in the per capita net income before and after the implementation of rural e-commerce poverty alleviation were analyzed. At present, the income sources of rural households in Zhumadian area were mainly agricultural income obtained from agricultural production, wage income obtained by going out or working nearby, income from land transfer, capital purchase and so on,transfer income from national preferential policies. The wage income, property income, and transfer income were unified into non-agricultural income for the model significance test. Therefore, the per capita net income of the farmer for Y, the net income per capita agricultural operation for YN, and the net non-agricultural income for YF were respectively taken as the explanatory variables to analyze the net

impact of rural e-commerce poverty alleviation on the income of participating farmers. According to the year for the surveyed farmers to participate in the rural e-commerce poverty alleviation mainly in 2016 and the accuracy of the farmers' past income records, the year of income of the households before and after the survey was selected as 2015 and 2017.It could more accurately measure the direction and impact of rural e-commerce poverty alleviation on farmers' income and income structure. Therefore, this paper used a total of 400 samples farmer income data in 2015 and 2017.

The statistical description of the main explanatory variables in this paper is shown in Table 7. The minimum value of Y, YN, and YF is 0 Yuan. The main reasons might be those interviewed farmers cannot be engaged in agricultural production or go out to work nearby due to their ages and serious illness. The maximum values of Y, YN, and YF were 13718.2 Yuan, 3823.3 Yuan, and 15800 Yuan.The average values of Y, YN, and YF were 6729.27 Yuan, 1441.22 Yuan, 5288.05 Yuan.The standard deviation was 4164.29 Yuan, 705.53 Yuan, and 3732.75 Yuan. The maximum value of YF was as high as 15,800 Yuan. The main reason might be that the interviewed farmer not only transferred the household contracted farmland to the special agricultural product planting base established by the e-commerce enterprise, but also obtained a stable land transfer fee and also got priority to work in the base. More family members were allowed to work nearby, go out to work, extend the time spent on work, and obtain higher income from work.Thereby substantially the non-agricultural income of farmers' families was increased.

Table 7. Statistical description of the dependent variables

Dependent Variable	Minimum	Maximum	Mean	Standard Deviation
the per capita net income of the farmerY （yuan）	0	13718.2	6729.27	4164.29
the net income per capita agricultural operationYN（yuan）	0	3823.3	1441.22	705.53
the net non-agricultural incomeYF（yuan）	0	15800	5288.05	3732.75

5.1.2 Model estimation results and explanation

Table 8 shows that from the perspective of per capita net income before the implementation of rural e-commerce poverty alleviation, the per capita net income of participating households was 4181.83 Yuan, while the per capita net income of the non-participating households was 3502.55 Yuan, the former was 679.28 Yuan more than the latter. The income level was not much different. After the implementation of rural e-commerce poverty alleviation, the per capita net income of participating households was 11,231.53 Yuan, and the per capita net income of non-participating households was 4494.27 Yuan. The former was 6278.26 Yuan more than the latter. The difference between the previous differences was 5,067.98 Yuan.That is, DID value was 5,067.98 Yuan. After the implementation of rural e-commerce poverty alleviation, the per capita net income of participating households increased by 7047.70 Yuan than before the implementation, while the per-capita net income of non-participating households increased slightly. After the implementation, the increase was only 1441.72 Yuan before the implementation. It showed that the positive net impact of rural e-commerce poverty alleviation on the per capita net income of farmers was 5607.98 Yuan.

From the perspective of net income per capita agricultural operation, before the implementation of rural e-commerce poverty alleviation, the per capita agricultural operating net income of participating households was 869.88 Yuan, while the non-participating households were 773.23 Yuan, the difference between the two was 96.65 v, which showed that between participating households and the non-participating households it was not different much before the implementation. After the implementation of rural e-commerce poverty alleviation, the per capita agricultural operating net income of participating households was 2146.83 Yuan, while the non-participating households were 1318.83 Yuan, the difference between participating households and the non-participating households was 828 Yuan. It can be seen that the participation of households and non-participating households differed greatly after implementation. Compared with before the implementation, the difference was 731.35 Yuan.That is, DID value is 731.35 Yuan.It indicated that the positive net impact of rural e-commerce poverty alleviation on the per capita agricultural net income of households was 731.35 Yuan.

From the perspective of per capita non-agricultural net income, after the implementation of rural e-commerce poverty alleviation, the per capita agricultural operating net income of participating households was 9084.69 Yuan, an increase of 5772.74 Yuan than that before the implementation, showing that rural e-commerce poverty alleviation was involved. Theinfluence to per capita agricultural operating net income of farmers was very significant.The per capita agricultural operating net income of non-participating households was 3,256.44 Yuan, which was only 896 Yuan more than before the implementation. The change was not so much. The difference of added value of operating net income between the per capita agriculture of participating farmers and non-participating farmers was 4,876.74 Yuan, which indicated that the positive net impact of rural e-commerce poverty alleviation on the per capita non-agricultural net income of farmers was 4,876.74 Yuan. Among them, the per capita non-agricultural net income of participating farmers was 9084.69 Yuan, a net increase of 5772.74 Yuan than that of before the implementation, with a growth rate of 174%.

Table 8. Mean difference of income of farmers before and after participation

The per capita net income of the farmerY（Yuan）	**Participating farmers**	**Non-participating farmers**	**Diff**
2015	4181.83	3502.55	679.28
2017	11231.53	4944.27	6287.26
Diff	7049.70	1441.72	5607.98
the net income per capita agricultural operationYN（Yuan）	participating farmers	non-participating farmers	Diff
2015	869.88	773.23	96.65
2017	2146.83	1318.83	828.00
Diff	1276.95	545.60	731.35
the net non-agricultural incomeYF（Yuan）	participating farmers	non-participating farmers	Diff
2015	3311.95	2729.31	582.64
2017	9084.69	3625.44	5459.25
Diff	5772.74	896	4876.74

5.1.3 DID model estimation results

The following is a significant test of the DID estimates in Table 9 using SPSS (20.0) software. The results are shown in Table 9.

Table 9. Significance test results

Variable	Coefficient	Y	YN	YF
C（cons）	α	3502.545***	773.233***	2729.313***
T	β	679.289	96.652	582.637
P	λ	1441.724***	545.597***	896.127**
TP	θ	5607.967***	731.351***	4876.615***
R^2		0.617	0.600	0.541

Note: *, **, and *** indicate significant levels at 10%, 5%, and 1%respectively.

Table 9 shows the DID coefficients of Y, YN, and YF are 5607.967, 731.351, and 4876.615 respectively.And all of them are significant at the 1% level. The coefficient λ of P is 1441.724, 545.597, and 896.127 respectively. And the former two are significant at the 1% level, and the latter is significant at the 5% level. These demonstrate that rural e-commerce poverty alleviation has a significant positive impact on farmers' net income, agricultural net income, and non-agricultural net income. That is, after the implementation of rural e-commerce poverty alleviation, agricultural operating income, and non-agricultural income have all increased significantly between the treatment group and the natural group income.

5.2 An Empirical Analysis of the Impact of Other Control Variables on Farmers' Income

5.2.1 Model design and variable selection

In the above model, the effects of individual and family factors on the income of farmers are neglected. In order to increase the accuracy of this study, a fixed-effects model is used to study the evidence, as shown in equation (7):

$$Y_{fs} = \alpha + \beta T_s + \lambda P_f + \theta T_s P_f + X_{fs} + \varepsilon_{fs} \quad (7)$$

Where f is the famer household, s is the period.Y_{fs} is the per capita income of the farmer f during the s period. Pf indicates whether the farmer f participates in the dummy amount of the rural e-commerce poverty alleviation.That is, participation in means P_f=1, not participating in means Pf=0.$T_s$is a dummyvariable about farmers participate in the dummy quantity before and after rural e-commerce poverty alleviation.That is, before participation meansT_s =0, and after participationT_s =1. X_{fs} is a set of observable variables that affect the income of farmers, including the age, gender, whether or not the head of household, education level, the total number of family members, the proportion of non-agricultural labor, and the area of cultivated land. ε_{fs} is another influencing factor that affects the income of farmers but is unobservable.

The independent variables include the three dummy variables (T, P, TP), the personal factors of the farmers and the family factors.The personal factors include the age, gender, whether or not the head of household, education level.Family factors include the total number of family members, the proportion of non-agricultural labor, and the area ofcultivated land. Assume that X1 is the age of the farmer, X2 is the gender, X3 is “whether or not the

head of household", X4 is the education level, X5 is the total number of family members, X6 is the non-agricultural labor ratio, and X7 is the family cultivated land (Mu).

5.2.2 Model results and interpretation analysis

Using SPSS 20.0 software and fixed effect mode $\mathbf{Y_{fs}} = \boldsymbol{\alpha} + \boldsymbol{\beta}\mathbf{T_s} + \boldsymbol{\lambda}\mathbf{P_f} + \boldsymbol{\theta}\mathbf{T_s}\mathbf{P_f} + \mathbf{X_{fs}} + \boldsymbol{\varepsilon_{fs}}(7)$, regression analysis was performed on the income of all surveyed households. The results are shown in the following table:

Table 10. Model estimation results for the main control variables

Variables	Y	Y_N	Y_F
age X_1	-6.623	2.781	-9.044
gender X_2	155.459	122.731	32.728
whether or not the head of household X_3	-237.182	-71.437	-165.745
education level X_4	506.509**	57.708	448.800**
the total number of family members X_5	1135.696***	19.374	1116.322***
the non-agricultural labor ratio X_6	9986.067***	1174.862***	8811.205***
the family cultivated land（Mu）X_7	94.371	71.706***	22.665
C（cons）	-2296.118*	316.302	-2612.419**
R2	0.524	0.256	0.526

Note: *, **, and *** indicate significant levels at 10%, 5%, and 1%, respectively.

Table 10 shows that the age of farmers has a negative impact on the per capita net income of farmers and the net non-agricultural income per capita, but they are not significant.The age has a positive impact on the net income of per capita agricultural operations, and it is not significant. "whether or not the head of household" has a negative impact on the per capita net income of farmers, net income per capita agricultural operation, and per capita non-agricultural net income, but and they are not significant. The education level has a significant positive impact on the per capita net income and per capita non-agricultural net income of farmers at the level of 5%.The total number of family members has a significant positive impact on the per capita net income, and the net non-agricultural income per capita at the level of 1%. The non-agricultural labor ratio has a significant positive impact on the farmer's per capita net income, the per capita farmer's operating net income, and the per capita non-agricultural net incomeat the level of 1%. The family cultivated land areais significant for per capita agriculture at the level of 1%.

5.3. The Impact of Rural E-commerce Poverty Alleviation on Farmers' Income Structure

Table 11 shows that the per capita agricultural net income, per capita net income, and per capita net income of per capita farmers accounted for 20.80%, 77.49%, and 1.71% respectivelyafter the implementation of poverty alleviation in rural e-commerce. While the ratioswere 22.08%, 75.81%, 2.11% respectively before the implementation of poverty alleviation in rural e-commerce.Per capita agricultural operating net income, per capita property net income decreased by 1.28 and 0.4 percent, and per capita wage net income increased by 1.68 percent. Those showed that the change of family income structure of non-participating households was not significant in the period of the implementation of rural e-commerce poverty alleviation. For the participating households, the per capita wage net income and per capita property net income accounted for 73.10% and0.22% before the

implementation of rural e-commerce poverty alleviation, and 76.97%, and 3.92% after the implementation of rural e-commerce poverty alleviation.It was an increase of 3.87 percent and 3.7 percent respectively. Per capita agricultural operating net income accounted for 26.68% and 19.11% respectively. It was a decrease of 7.57 percent. The household income structure of participating households had changed significantly comparing with that before and after the implementation of rural e-commerce poverty alleviation.And the income sources were more diverse. The ability of famers to continue to increase revenue had increased significantly.

Table 11. Changes in income structure of farmers

Income structure	Participating farmers		Non-participating farmers	
The net income per capita agricultural operation（Yuan）	22.08%	20.80%	26.68%	19.11%
The net income per capita wage（Yuan）	75.81%	77.49%	73.10%	76.97%
Per capita property net income（Yuan）	2.11%	1.71%	0.22%	3.92%
Sum	100%	100%	100%	100%

6. DISCUSSION

As a new way of poverty alleviation, rural e-commerce poverty alleviation has not been widely promoted in poverty-stricken areas in most developing countries, and relevant theories are lacking. This study uses the DID model to draw lessons from e-commerce poverty alleviation.This study studies the systematic impact of rural e-commerce on the net income per capita of farmers, per capita agricultural net income, and per capita non-agricultural net income, and the impact on farmers' income structure. It is an innovation in empirical research.

Based on the above analysis, based on the in-depth analysis of the shortcomings and shortcomings of the existing research results, this search uses the DID model to empirically analyze the per capita net income of rural e-commerce poverty alleviation, per capita agricultural net income, per capita. The non-agricultural net income and the influence direction of the income structure and the degree of influence, and on this basis, in order to further accelerate the development of the rural e-commerce industry in the Zhumadian area and implement the rural e-commerce poverty alleviation project, put forward corresponding policy recommendations.This shows that policy interventions have a theoretical and practical significance for e-commerce to alleviate poverty and narrow the income gap.

7. CONCLUSION

The rural e-commerce poverty alleviation has a significant effect on farmers' income. The rural e-commerce poverty alleviation can greatly increase the agricultural operation income and non-agricultural income of the participating farmers, so as to increase the total income of the participating households. Thus it could help the participating farmers to increase income and get rid of poverty.

The rural e-commerce poverty alleviation has long-term effects on farmers' income. From the field research, the non-agricultural income of farmers mainly included wage income, land transfer fees, dividends for enterprises, and so on. The farmers achieved stable employment

by participating in offline production activities of local network operators.They sign land transfer agreements with agricultural product e-commerce enterprises, and obtain stable annual transfer costs. They applied for poverty alleviation microfinance and invested in local poverty alleviation e-commerce enterprises to get a fixed annual corporate dividend. Poverty township government and local leading e-commerce enterprises signed cooperation agreements to guide them to sign acquisition contracts with poor farmers, which promised to buy agricultural products produced by poor farmers at higher than market prices.It helped poor farmers to improve agricultural operating income.

The rural e-commerce poverty alleviation can optimize the household income structure of farmers in the short term. It can increase the wage income and property income of participating farmers by increasing the opportunities for nearby employment, extending the time of working outside the home, accelerating the transfer of contracted farmland, and capital stocks toincrease the wage income and property income of participating farmers. It reduced agricultural income significantly toexpand the income source of farmers and optimize the family income structure.

The limitation of this study is that although the DID model gives a quantitative analysis conclusion of e-commerce poverty alleviation, in terms of theoretical construction, the e-commerce poverty alleviation mechanism still needs further exploration. In addition, in reality, how to reduce policy costs and improve the marginal efficiency of e-commerce poverty alleviation policy is also an important research direction in the future. Finally, for the advent of the 5G era, e-commerce poverty alleviation will also face new challenges and opportunities, all of which have significant research value.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

Q. Z. designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. N. Y. suggested research ideas and contributed to the data analysis and revision of the paper. Z. F., and H. J. managed the literature searches, and were responsible for questionnaire collection and data processing.

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