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Research on the Income Growth Effect of Farmers' Participation in E-commerce in Poor Areas

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Abstract: With the continuous development of e-commerce in China's rural areas, whether e-commerce can increase farmers' income has been paid more and more attention. Based on the field investigation of farmer households in two counties of Guangxi, this paper analyzes the correlation between farmers' participation in e-commerce decisions and the income level of farmers' families, and uses the endogenous transformation model to make an empirical analysis of the income level gap between farmers' participation in e-commerce and farmers' non-participation in e-commerce samples. The results show that the income level of farmers who participate in e-commerce of agricultural products is significantly higher than that of farmers who do not participate in e-commerce. The counterfactual hypothesis analysis results show that the adoption of e-commerce may significantly increase farmers' total household income by 10.3% and planting income by 11.3%. The adoption of e-commerce will widen the income gap among farmers. Under the assumption of rational smallholder farmers, this gap is the income increase effect of the adoption of e-commerce.

1. Introduction

In recent years, with the gradual improvement of China's transportation and Internet infrastructure, the layout and development of e-commerce in China's rural areas have been greatly accelerated. In fact, with the development of rural Internet and the implementation of a series of policies to benefit agriculture, China's rural e-commerce continues to grow rapidly. In 2020, China's rural online retail sales reached 1.79 trillion yuan, accounting for 15% of the country's total online retail sales, with a year-on-year growth of 8.9%. Among them, physical retail sales in rural areas reached 1.63 trillion yuan, accounting for 91 percent of the country's rural online retail sales, up 10.5 percent year on year. Through the innovation of business flow and information flow, rural e-commerce breaks the regional restrictions of agricultural products, changes the inherent employment mode of farmers, and gradually becomes an important practice for farmers to stabilize and broaden the existing channels of income increase[1]. Especially, with the rapid application of the e-commerce sales mode of "live streaming with goods" to the marketing of agricultural products, it has become a new form of rural e-commerce, which is highly concerned by the government decision-making level. According to the No.1 Document of the CPC Central Committee in 2021, we will further promote the introduction of e-

commerce into rural areas and agricultural products out of rural areas into cities, so as to effectively link urban and rural production and consumption. The country has turned the e-commerce of agricultural products into an important means to consolidate the achievements of poverty alleviation and promote rural revitalization. Does the widespread penetration of e-commerce of agricultural products in poor areas have a synchronous trend with the increase of farmers' income? Has it played an effective role in promoting the growth of farmers' income? What is the impact? These are urgent questions. Based on the historical background of consolidating the achievements of poverty alleviation and helping rural revitalization, this paper evaluates the impact of participating in e-commerce from the perspective of farmers' income level based on the survey data of two counties in Guangxi, which is of great significance for vigorously developing agricultural e-commerce to help rural revitalization.

2. Literature review

Existing researches on rural e-commerce mainly focus on its influencing factors and effects, and there are abundant researches on farmers' income increase. First of all, the factors affecting the adoption of agricultural products e-commerce are diverse and complex. For example, information literacy will promote farmers' participation in e-commerce by improving their perceived usefulness and perceived ease of use in e-commerce of agricultural products [2]; Social network has a significant positive effect on farmers' participation in e-commerce of agricultural products [3]. In addition, participation in e-commerce training, the highest family education, e-commerce labor ability, demographic characteristics, family attributes and geographical conditions can all influence farmers' behavior of adopting e-commerce[4-5]. Secondly, the impact of farmers' adoption of e-commerce is also very rich, especially in increasing farmers' incomes. For example, according to Ji 's (2022)study on the introduction of e-commerce into rural comprehensive demonstration counties, the construction of demonstration counties has significantly increased the average annual deposit of residents in the counties, with an increase between 220 yuan and 366 yuan[6]. Yu et al. (2021) found that after non-e-commerce farmers participate in e-commerce, their income level will increase by 7.93%[7]. In addition, some scholars have conducted specific studies on the impact of the adoption of agricultural products e-commerce on farmers' income in poor areas. For example, Wu (2021) shows that the adoption of e-commerce sales by farmers has a significant income effect, while the adoption of e-commerce sales by poor households has a significant and weak income increase effect[8]. Xiong (2022) proposed that farmers in poverty-stricken areas mainly integrate into e-commerce value chain as producers, and e-commerce can increase farmers' income by expanding product sales and prices[9]. Li (2021) believes that the income effect of e-commerce adoption is greater in the central and western regions than in the eastern regions and in the regions with high marketization level than in the regions with low marketization level, showing obvious regional heterogeneity[10]. Some studies also found that rural women broke through the traditional gender division of labor in the process of participating in the e-commerce of agricultural products [11], and significantly increased the labor income and proportion of rural women [12].

Based on the above conclusions, it can be seen that current academic circles agree that the development of e-commerce in rural areas can drive the increase of farmers' income on the issue of whether e-commerce can promote farmers' income. However, there is a lack of investigation and research on farmers whose plantation income is the main factor in the current literature. Therefore, this paper uses the survey data of mango and Shatian pomelo farmers in the poor mountainous areas of two counties in Guangxi, applies the endogenous transformation model to estimate the growth effect of e-commerce application on farmers' income, discusses the influence of e-commerce adoption behavior on their plantation income, and fills the research gap.

3. Theoretical analysis and research hypotheses

3.1 The impact of farmers' participation in e-commerce on income increase effect

Schulz's rational smallholder hypothesis holds that farmers' behavior is to pursue the maximization of interests, which is rational. Before implementing a certain behavior, farmers will conduct a comprehensive study and judgment on the time, manpower, economic and other costs to be paid for the implementation of the behavior as well as the expected benefits brought by the implementation of the behavior. Only when the expected benefits of participating in e-commerce are higher than the profits of the traditional business model, farmers will implement the behavior. However, in terms of the advantages of e-commerce at present, on the one hand, e-commerce of agricultural products can enable farmers to know the general demand in the market in advance and make production scale in advance according to the demand, so as to reduce unnecessary losses or invisible losses caused by insufficient supply and effectively reduce intermediate costs [13]. In traditional agricultural operation mode, farmers mostly choose to sell agricultural products to intermediaries due to information asymmetry and other factors, and the price of agricultural products sold by farmers is lower than the actual market price, resulting in huge intermediate costs in the traditional operation process. However, the application of e-commerce of agricultural products no longer requires middlemen to participate in the transaction process, and farmers can directly connect with consumers through e-commerce platforms to improve operating profits. On the other hand, e-commerce of agricultural products can improve farmers' income by reshaping the value of agricultural products. Due to the low added value of agricultural products and the short industrial chain, the price under the traditional business model is determined by the market supply and actual demand, and farmers' agricultural products are passively accepted in the sales process. The introduction of e-commerce makes the production, processing, packaging and sales of agricultural products more standardized. Through a series of commercial packaging, traditional agricultural products will be rebuilt, and the corresponding market price will increase with the upgrade of agricultural products, and the profits will also increase. Based on the above analysis, research hypothesis H1 is proposed: farmers' participation in e-commerce of agricultural products has income-increasing effect.

3.2 The impact of farmers' participation in e-commerce on income gap

In the existing research, there is controversy about the effect of e-commerce on the income gap of farmers. For example, the study of some scholars shows that the involvement of e-commerce expands the income gap among farmers [14], while Zhang et al. (2021) believe that participation in e-commerce can narrow the income gap among participants[15]. The ways for e-commerce to increase farmers' income include expanding product sales, reducing operating costs, raising product selling prices, etc. To improve farmers' income through these mechanisms, more rely on farmers' operating ability. If farmers have excellent offline operation ability, they are likely to enlarge their advantages in operation ability through e-commerce after adopting e-commerce, form strong competitiveness and realize the increase of income. On the contrary, if farmers' offline operation ability is weak, the adoption of e-commerce may amplify this weakness, which is very likely to lead to an insignificant increase in income or even a decline in income. Under the condition that there is a threshold for the adoption of e-commerce to increase income, the adoption of e-commerce as a "leverage" tool may widen the income gap among farmers. Based on this, this paper puts forward hypothesis H2: Participation in e-commerce of agricultural products widens the income gap of farmers.

4. Data source and model construction

4.1 Data source

The data used in this paper are from the team's field research in Baise and Rong County, Guangxi in 2020. Guangxi, as China's "fruit kingdom", has the characteristics of large yield, excellent quality and complete categories of fruits. Because fruits are not durable in storage and the rugged and complicated terrain makes it difficult to export, fruit growers in Guangxi have been faced with the problem of unmarketable products. E-commerce is a new way to solve this problem. Among many fruits in Guangxi, Rongxian Shatian pomelo and Baise Mango are the outstanding ones. They all belong to China's National Geographic indication products with excellent quality and rich nutrition. They have natural advantages in adopting e-commerce sales and are easier to form good e-commerce adoption effect and set a model. Therefore, the team took Guangxi as the target site of investigation, took the farmers of Shatian pomelo and Baise mango in Rongxian County, Guangxi as the object of investigation, investigated their e-commerce adoption status and income situation, so as to study the influencing factors and income adjustment effect of e-commerce adoption by farmers of geographical indication agricultural products in backward areas. In this survey, a total of 176 questionnaires were distributed.

4.2 Variable design and descriptive statistics

1) Explained variables

The explained variables in this paper are farmers' income, including total family income and planting income. The study collected the income data of farmers of geographical indication agricultural products from 2019 to 2021, and constructed models of total household income and planting income after logarithmic processing.

2) Core explanatory variables

In this paper, whether farmers adopt e-commerce or not is taken as the core explanatory variable of the income outcome equation. If they adopt e-commerce, it is 1, and if they do not, it is 0. Meanwhile, in the behavior selection equation, whether farmers adopt e-commerce or not is the explained variable.

3) Control variables

The factors affecting farmers' participation in e-commerce are diverse, and existing studies have classified them according to different methods. In this study, the classification method proposed by Wang (2021) was adopted, and the influencing factors were divided into individual characteristics, family characteristics and geographical conditions[5]. Individual characteristics include age, gender, education level, training, prior experience, e-commerce risk attitude. Household characteristics include the number of people working at home, whether they are poor, and geographical conditions include the distance to the nearest town. Risk attitude, as an instrumental variable, solves the endogeneity problem of the model's core explanatory variable. Intuitively, e-commerce risk attitude does not directly affect farmers' income, and is closely related to whether farmers adopt e-commerce to meet the requirements of the externality and correlation of instrumental variables. The measurement method has passed the weak instrumental variable test.

Table 1 shows the descriptive statistical results of dependent variables and control variables of farmers participating in e-commerce and farmers not participating in e-commerce. It can be seen that the income level of farmers participating in e-commerce is 110,600 yuan, while that of farmers not participating in e-commerce is 105,800 yuan. The income level of farmers participating in e-commerce is significantly 40,800 yuan higher than that of those not participating in e-commerce. In terms of control variables, there are significant differences between farmers participating in e-

commerce and those not participating in e-commerce in terms of gender, education level, entrepreneurial experience, whether they are village cadres, participation in e-commerce training, distance from town to town, and attitude towards e-commerce risks. In terms of age, e-commerce farmers are younger than non-e-commerce farmers. Farmers who participate in e-commerce have higher education level, richer entrepreneurial experience, have served as village cadres, participated in more e-commerce training, are closer to the town, and are more optimistic about the risks of e-commerce. However, there is no significant statistical difference between the two groups of farmers in terms of family labor force.

Table 1: Variable design and descriptive statistics.

Variable	Definition	Adopt		Not adopted	
		Mean	S.D	Mean	S.D
Household income	Actual income logarithm	11.06	0.52	10.58	0.73
Planting income	Actual income logarithm	10.61	0.63	10.09	0.72
Age	Number of actual age	41.93	5.81	48.84	9.18
Sex	1=Male and 0=female	0.69	0.47	0.44	0.50
Degree of education	1= never attended school, 2= primary school, 3= junior high school, 4= senior high school or above	3.16	0.63	2.55	0.72
Village cadres	1=Yes and 0=No	0.17	0.38	0.05	0.22
Entrepreneurs hip experience	1=Yes and 0=No	0.31	0.47	0.12	0.33
E-commerce training	1= not participating, 2=1 in 1 year, 3=1 in season, 4=1 in January	2.14	0.82	1.14	0.41
The number of labor	The actual number	2.32	1.01	2.31	1.04
Low income family	1=Yes and 0=No	0.11	0.32	0.24	0.43
To the town distance	Actual distance (km)	12.07	4.99	18.35	7.22
E-commerce risk attitude	1= high, 2= higher, 3= general, 4= lower, and 5= low	3.67	1.19	2.80	0.77

4.3 Model construction

4.3.1 Model of the effect of farmers' e-commerce participation on income increase

For the endogenous problem of whether farmers adopt e-commerce, the endogenous transformation model can reduce selection bias and improve the estimation accuracy by controlling observable and unobservable variables. ESR includes the selection equation and the structural equation of the result equation.

First, the baseline regression model between e-commerce adoption and household income is constructed as follows:

$$Y = \beta_0 + \beta_1 D + \alpha X + \mu \quad (1)$$

Among them, the explained variable Y is the income of farmers; D indicates whether the e-commerce sales of agricultural products, farmers adopt the e-commerce sales D=1, and if not D=0; X represents the vector of observable variables that affect the family income of farmers, mainly including personal characteristic variables such as age, cultural level, previous experience, risk

attitude, as well as family characteristic variables such as home labor force. β_i and α are the parameters to be estimated, in which β_1 is the revenue increase effect of e-commerce; μ is a random disturbance term.

Secondly, because whether farmers adopt e-commerce is a self-choice behavior, there may be unobservable factors and influence means that D_i is an endogenous variable, so it is necessary to construct a behavior selection equation for farmers to adopt e-commerce sales, as follows:

$$\begin{cases} D_i = 1 & \text{if } D_i^* = \gamma_i Z_i + v_i > 0 \\ D_i = 0 & \text{if } D_i^* = \gamma_i Z_i + v_i \leq 0 \end{cases} \tag{2}$$

In Equation (2), D_i^* is a latent variable, which means to adopt the net income of agricultural products sold by e-commerce. When $D_i^* > 0$, farmers will adopt e-commerce to sell agricultural products. At this time, $D_i^*=1$, otherwise $D_i^*=0$. Z_i is a vector of explanatory variables that affects the decision of farmers' e-commerce, and at least one explanatory variable in Z_i is different from X in (1), γ_i is the parameter to be estimated, and v_i is a random interference term.

Thirdly, construct farmer income result equations for agricultural products sold by e-commerce and farmer income result equations for agricultural products sold by e-commerce:

$$Y_{Di} = \beta_{Di} + \alpha_{Di} X_{Di} + \mu_{Di}, if \ D_i=1 \tag{3}$$

$$Y_{noDi} = \beta_{noDi} + \alpha_{noDi} X_{noDi} + \mu_{noDi}, if \ D_i=0 \tag{4}$$

Y_{Di} and Y_{noDi} represent the farmers' income of agricultural products adopted and not adopted by e-commerce, while Y_{Di} and Y_{noDi} indicate the observable variables affecting the planting income and total household income of farmers in the adopted and unadopted groups, respectively.

Finally, since the empirical research of income is usually treated logarithmically, the farmers' income is treated logarithmically, and the following endogenous conversion model is obtained:

$$ln(Y_{Di}) = \beta_{Di} + \alpha_{Di} X_{Di} + \mu_{Di}, if \ D_i=1 \tag{5}$$

$$ln(Y_{noDi}) = \beta_{noDi} + \alpha_{noDi} X_{noDi} + \mu_{noDi}, if \ D_i=0 \tag{6}$$

4.3.2 Income gap calculation model of farmers' e-commerce participation

After estimating the parameters of the model, the unconditional expectations of two groups of farmers who adopt and do not adopt can be calculated:

$$E(ln(Y_{Di})|X_{Di}) = \hat{\beta}_{Di} + \hat{\alpha}_{Di} X_{Di} \tag{7}$$

$$E(ln(Y_{noDi})|X_{noDi}) = \hat{\beta}_{noDi} + \hat{\alpha}_{noDi} X_{noDi} \tag{8}$$

Since the model income is processed logarithmically, Equation (9) can be used to approximate the income gap between farmers who adopt and those who do not adopt e-commerce after estimating the model:

$$\text{DIFF} = \frac{1}{N} \sum_{i=1}^{N} \frac{e^{lnY_{Di}} - e^{lnY_{NODi}}}{e^{lnY_{Di}}} \tag{9}$$

4.3.3 Calculation of average treatment effect of farmers' income

Considering the possibility of self-selection bias in farmers' adoption of e-commerce, it is necessary to further estimate farmers' conditional income expectation and counterfactual expectation, so as to estimate the average processing effect of farmers' adoption of e-commerce.

Expected logarithmic income of farmers adopting e-commerce:

$$E(ln(Y_{Di})|D_i = 1) = \hat{\beta}_{Di} + \hat{\alpha}_{Di} X_{Di} \tag{10}$$

Expected logarithmic income of farmers who have not adopted e-commerce:

$$E(ln(Y_{noDi})|D_i = 0) = \hat{\beta}_{noDi} + \hat{\alpha}_{noDi}X_{noDi} \quad (11)$$

The expected logarithmic income of farmers who adopt e-commerce without it:

$$E(ln(Y_{noDi})|D_i = 1) = \hat{\beta}_{noDi} + \hat{\alpha}_{noDi}X_{Di} \quad (12)$$

The expected logarithmic income of farmers who do not adopt e-commerce if they adopt e-commerce:

$$E(ln(Y_{Di})|D_i = 0) = \hat{\beta}_{Di} + \hat{\alpha}_{Di}X_{noDi} \quad (13)$$

Expected logarithmic income of all farmers if they adopt e-commerce:

$$E(ln(Y_{Di})) = \hat{\beta}_{Di} + \hat{\alpha}_{Di}X \quad (14)$$

Expected logarithmic income of all farmers without e-commerce:

$$E(ln(Y_{noDi})) = \hat{\beta}_{noDi} + \hat{\alpha}_{noDi}X \quad (15)$$

The average treatment effect of farmers' income in the difference between (10) and (12) adopting e-commerce:

$$ATT = E(ln(Y_{Di})|D_i = 1) - E(ln(Y_{noDi})|D_i = 1) \quad (16)$$

The average treatment effect of (11) and (13) on the income of farmers who have not adopted e-commerce:

$$ATU = E(ln(Y_{noDi})|D_i = 0) - E(ln(Y_{Di})|D_i = 0) \quad (17)$$

Average treatment effect of farmers' income in the whole sample of difference fields (14) and (15):

$$ATE = E(ln(Y_{Di})) - E(ln(Y_{noDi})) \quad (18)$$

ATT and ATU indicate that the potential effect of e-commerce adoption decisions can not only consider the average treatment effect of income levels of the two types of farmers' e-commerce adoption decisions, but also be used to evaluate whether farmers' adoption of e-commerce to sell agricultural products is in line with economic rationality. ATE measures the average treatment effect of the whole sample of farmers.

5. Empirical test and result analysis

5.1 Analysis of income effect of farmers adopting e-commerce

In this paper, stata16 was used to estimate equations (2), (5) and (6), and the results were shown in Table 2. ρ_{DV} and ρ_{NODV} represent the correlation coefficients between the random disturbance item of the behavior selection equation and the income result equation of farmers who adopt e-commerce and the random disturbance item of farmers who do not adopt e-commerce, respectively. The ρ_{DV} of model 1 and model 2 are both positive and significant, indicating that the income of farmers who adopt e-commerce to sell agricultural products is significantly higher than that of farmers who do not adopt e-commerce to sell agricultural products in the sample. ρ_{NODV} is all negative, but not significant means that the income of farmers who do not adopt e-commerce is lower than that of other farmers in the sample. As long as one of ρ_{DV} and ρ_{NODV} is significant, it indicates that there is a self-selection problem in the sample, and ρ_{DV} is significantly greater than 0 in both model 1 and model 2, indicating that the e-commerce adoption decision of geographical indication product growers is not random, but a self-selection behavior influenced by unobservable factors. At the same

time, the likelihood ratio tests of model 1 and Model 2 are significant at the 10% level, rejecting the assumption that the behavior selection equation and the income outcome equation are independent of each other. This indicates that it is appropriate to choose ESR model to analyze the impact of factors including e-commerce adoption decisions on the income of growers of geographical indication products.

Table 2: Farmers adopt the income effect of e-commerce.

	Total income (Model 1)			Planting income (Model 2)		
Variable	Adopt	Not adopted	Select Equation 1	Adopt	Not adopted	Select Equation 1
Degree of education	0.311*** (5.94)	0.186*** (3.18)	0.443*** (3.24)	0.471*** (7.74)	0.148*** (2.71)	0.427*** (3.14)
Village cadres	-0.008 (-0.10)	0.138 (0.88)	-0.727** (-2.45)	-0.129 (-1.35)	0.093 (0.61)	-0.604** (-2.08)
Entrepreneurship experience	0.056 (0.98)	0.305*** (2.97)	0.047 (0.25)	0.153** (2.30)	0.313*** (3.02)	-0.048 (-0.25)
E-commerce training	0.302*** (7.27)	0.058 (0.34)	1.277*** (9.14)	0.359*** (7.32)	0.045 (0.35)	1.261*** (8.93)
To the town distance	-0.036*** (-5.54)	-0.010* (-1.66)	-0.060*** (-4.21)	-0.038*** (-5.00)	-0.014*** (-2.74)	-0.058*** (-4.08)
Age	0.003 (0.61)	-0.016*** (-3.99)	-0.020* (-1.86)	0.003 (0.50)	-0.018*** (-4.53)	-0.022** (-1.99)
Sex	0.144*** (2.59)	-0.227*** (-3.07)	0.442*** (2.87)	0.049 (0.76)	-0.190*** (-2.70)	0.459*** (2.95)
The number of labor	0.113*** (3.88)	0.113*** (3.41)	-0.136* (-1.78)	0.119*** (3.51)	0.106*** (3.31)	-0.120 (-1.61)
Low income family	-0.195** (-2.77)	-0.361*** (-4.26)	-0.554** (-2.36)	-0.185** (-1.99)	-0.37^{9}*** (-4.61)	-0.585** (-2.55)
E-commerce risk attitude			0.125* (1.69)			0.165** (2.42)
Cons	9.238*** (32.97)	10.885*** (33.52)	-1.711** (-2.13)	8.220*** (25.17)	10.694*** (32.79)	-1.772** (-2.17)
Lnsigma	-0.942*** (-12.89)	-0.619*** (-14.29)		-0.796*** (-11.09)	--0.615*** (-14.80)	
ρ_{DV}	0.804***			0.774***		
ρ_{NODV}		-0.091			-0.025	
LR test of indep. eqns		chi2(1) = 2.99 Prob = 0.084				chi2(1) = 3.23 Prob = 0.072

Note: *, * * and * * * are significant at the 10%, 5% and 1% levels, respectively.similarly hereinafter.

According to the results of selection equation 1 and equation 2 in Table 2, it can be seen that education level, e-commerce training, gender, and distance from family to town affect farmers' e-commerce adoption decisions at the significance level of 1%. The higher the education level of farmers and the more frequently they participate in e-commerce training, the easier it is to adopt e-commerce to sell agricultural products. The farther the family is from the town, the less easy it is to adopt e-commerce. The experience of village cadres and the experience of poor households affected farmers' e-commerce adoption decisions at a significant level of 5%. Age and risk attitude towards e-commerce are significant at the 10% level in choice equation 1 and at the 5% level in choice equation 2.

In total income model 1, it can be found that farmers who adopt e-commerce and farmers who do not adopt e-commerce have obvious differences in income increase effects caused by their influencing factors. Education level, distance from the family to the town, gender, the number of labor force at

home, whether poor households have significant influence on the income of farmers who adopt and do not adopt e-commerce. Among them, the number of laborers at home and the distance from the family to the town have little difference on the income of the two groups of farmers. The more laborers at home, the more total income of the family, and the farther the family is from the town, the less total income of the family. But education had a significantly greater impact on the income of smallholder farmers who adopted e-commerce. People with high education level have stronger learning and thinking ability. E-commerce can enrich the sales channels and information acquisition channels of agricultural products and give better play to their advantages. E-commerce training has a significant impact on the income of farmers who adopt e-commerce, but has no significant impact on the income of farmers who do not adopt e-commerce. Entrepreneurial experience and age only had a significant impact on the income of farmers who did not adopt e-commerce. Farmers with entrepreneurial experience have richer social experience and social capital, which can better coordinate the relationship with upstream and downstream partners and promote the increase of income.

In planting income model 2, the significance and direction of factors such as education level, distance from family to town, e-commerce training, age, number of people and whether poor households remain unchanged, but the income increase effect gap between the adoption group and the non-adoption group is further widened. However, the gap between the two groups of farmers' income increase effect of gender narrowed and changed from significant to insignificant in the adoption group. Entrepreneurial experience had significant effects on both adopters and non-adopters.

5.2 Analysis of farmers' income gap and average treatment effect

According to the results in Table 3 below, the gap between the total household income and planting income of farmers who adopt e-commerce and those who do not is 40.1% and 54.2%, respectively. On the one hand, it shows that the income of farmers who adopt e-commerce is significantly higher than that of farmers who do not adopt e-commerce; on the other hand, it shows that the increase of planting income of farmers who adopt e-commerce is greater than the increase of total household income.

Table 3: Income gap between farmers who adopt e-commerce and those who do not.

	Total income	Planting income
Diff	0.401***	0.542***

Although Table 3 intuitively shows the income gap between farmers who adopt e-commerce and those who do not, the contribution of the decision to adopt e-commerce is still unknown. Because farmers who adopt e-commerce may be better than those who do not adopt e-commerce in terms of education level, age, number of laborers at home, e-commerce training, etc., the income gap shown in Table 3 is caused by a combination of many factors. In order to better analyze the actual contribution of e-commerce adoption decisions to farmers' income growth, counterfactual estimates are made on the income of sample farmers, and the results are shown in Table 4.

Table 4: Average treatment effect of farmers' income.

	ATT	ATU	ATE
Total income	0.103*** (2.69)	-0.544*** (-16.74)	-0.271*** (-8.10)
Planting income	0.113*** (2.67)	-0.670*** (-18.59)	-0.340*** (-8.92)

In Table 4, ATT is the average processing effect of the adoption group, and the difference between the logarithmic expected value of the actual income of farmers who adopt e-commerce and the logarithmic expected value of the counterfactual income of farmers who adopt e-commerce. ATT

values corresponding to total family income and planting income of farmers adopting e-commerce are 0.103 and 0.113, respectively, indicating that the adoption of e-commerce can significantly increase farmers' total family income by 10.3% and planting income by 11.3%. ATU is the average treatment effect of the group that has not adopted e-commerce, and is the difference between the logarithmic expected value of the actual income of farmers who have not adopted e-commerce and the logarithmic expected value of the counterfactual income of farmers who have not adopted e-commerce. The ATU values corresponding to the total household income and planting income of farmers who do not adopt e-commerce are -0.544 and -0.670, respectively, indicating that if the farmers who do not adopt e-commerce in the sample adopt e-commerce, their total household income and planting income will decrease by 54.4% and 67.0%, respectively. According to Liu et al. (2014), the inconsistency between ATT and ATU in direction indicates that there is a self-selection problem in individual choice decision-making, and the decision result is a rational decision based on comparative advantage[16]. In Table 4, ATT and ATU corresponding to household income model 1 and planting income model 2 are both greater than 0 and less than 0, which further indicates that there is a self-selection problem in whether farmers adopt e-commerce or not, and its decision result is rational, which verifies hypothesis 1.

By comparing the statistical indicators such as individual characteristics and family characteristics of farmers in Model 1 and Model 2, it is found that the indicators of the adopter group are obviously better than those of the non-adopter group. This indicates that there is a certain threshold for the adoption of e-commerce. If there is no relevant training or poor business ability determined by personal characteristics, family conditions and other factors, the adoption of e-commerce will not be conducive to income growth. However, if the corresponding threshold is reached, the adoption of e-commerce will significantly promote the increase of farmers' income. ATE is the average processing effect of the whole sample, which is the difference between the logarithmic expected income of the whole sample of farmers who adopt e-commerce and the logarithmic expected income of the whole sample of farmers who do not adopt e-commerce. In model 1 and model 2, ATE values are both less than 0, which indicates that the average income of farmers in the whole sample is far higher when they adopt e-commerce than when they do not. As it is rational for farmers to adopt e-commerce and there is a high threshold for adopting e-commerce to increase their income, rational farmers will make decisions to adopt e-commerce when they expect that adopting e-commerce will improve their income. Under objective conditions, farmers in backward areas that do not reach the corresponding threshold account for a large proportion of farmers in the region, so a large part of farmers will not adopt e-commerce, and some farmers who reach the threshold can use e-commerce to increase their income, which will inevitably widen the income gap among farmers, which verifies hypothesis 2.

6. Conclusions

Based on the field investigation of farmer households in two counties of Guangxi, this paper explores the relative influence of farmers' participation in e-commerce on family income and planting income through correlation analysis between farmers' participation in e-commerce and their family income. And through the empirical analysis of the endogenous transformation model proved that farmers participate in e-commerce and farmers do not participate in e-commerce income differences between two types of samples. The results showed that: first, 42% of the samples participated in e-commerce of agricultural products, and their income level was significantly higher than that of farmers who did not participate in e-commerce, indicating that participation in e-commerce of agricultural products effectively improved the income level of farmers. Second, according to the analysis results of counterfactual hypothesis, the adoption of e-commerce may significantly increase the total household income of farmers by 10.3% and the planting income by 11.3%, but to achieve

this effect, a high threshold of individual comprehensive quality needs to be met. Thirdly, the adoption of e-commerce will widen the income gap among farmers. Under the assumption of rational smallholder farmers, this gap is the income increase effect of adopting e-commerce.

According to the relevant conclusions, the following suggestions are put forward: first, strengthen the publicity of e-commerce, open the minds of farmers, expand and deepen the training of e-commerce, establish the training of expert teams to the countryside, focus on the small farmers in the management ability and other aspects of the special training, make up the small farmers in the adoption of e-commerce shortcomings, so that more farmers can enjoy the income effect brought by e-commerce. The second is to strengthen skills learning, deepen the adoption of e-commerce, across the threshold of income. In the process of adopting e-commerce to sell agricultural products, small farmers need to strengthen the learning of e-commerce product promotion, price negotiation, transportation, after-sales service and other skills to improve competitiveness and cross the threshold of e-commerce adoption to increase income. The third is to promote express service sites into the village, complete the express service. Transportation distance has a significant negative impact on the adoption of e-commerce and income, so it is necessary to further improve the construction of e-commerce logistics, promote express sites into villages, and make up for the lack of village express delivery services.

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