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ARTICLE

Influence of E-Commerce on Sales Performance of Mountainous Orange Farmers in Hubei Province, China

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ABSTRACT

Due to their distance from urban markets, many mountainous rural areas face the challenge of unsold agricultural products, which contributes to poverty and hinders development. E-commerce presents a significant new avenue for connecting farmers in these regions with broader online markets. This study uses survey data collected from orange growers in rural, mountainous China. An endogenous switching regression model was employed to assess the average treatment effects of e-commerce on agricultural sales performance within a counterfactual analysis framework. Next, a mediated effects model was used to verify the pathways through which e-commerce affects the sales performance orange farmers. The results indicate that: First, participating in e-commerce increases the sales performance of orange farmers by 9.57% to 12.47%. Second, the heterogeneity analysis found that social e-commerce platforms, such as WeChat and Weibo, have a greater positive impact on farmers' orange sales performance than e-commerce platforms, such as Jingdong and Taobao. Furthermore, the effect of e-commerce on improving sales performance is more pronounced for smallholder farmers. Third, e-commerce reduces information asymmetry and extends the product value chain and market scope in the orange marketing process. This results in reduced costs, increased value, and expanded markets, ultimately improving orange sales performance. These findings clarify the mechanisms through which e-commerce involvement affects agricultural sales performance in mountainous rural areas, providing practical insights for the development of agricultural e-commerce.

Keywords: E-Commerce; Marketing Management; Orange Growers; Sales Performance; Mountainous Rural

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1. Introduction

Mountainous rural areas have historically been hotspots for poverty. The root causes of this poverty are not only the challenging natural conditions, such as complex terrain, inconvenient transportation, and poor land quality, but also the physical distance from markets, which severely impedes the trading of agricultural products [1]. Due to the remoteness of these areas, the transportation costs for farm products from production sites to consumer markets are high, making it difficult for farmers to achieve reasonable economic returns through traditional market channels [2]. Furthermore, farmers often lack a timely understanding of market demand and price fluctuations, which leads to unsold or low-priced agricultural products, further exacerbating the cycle of poverty [3]. In traditional intermediary purchasing models, especially in regions dominated by smallholders with limited market access, agricultural product transactions involve multiple intermediaries. While these intermediaries can provide essential services such as aggregation, credit, and logistics, they may sometimes exploit information and location advantages to suppress procurement prices, thereby reducing farmers' profits. This situation highlights the need for alternative structures, such as cooperatives or digital platforms, to mitigate potential negative effects while preserving the beneficial roles of intermediaries [4].

The emergence of e-commerce has broken the limitations of geographical space, providing a new avenue for the sales of agricultural products in mountainous rural areas [5]. Rural e-commerce can reduce reliance on traditional intermediaries by directly connecting buyers and sellers, thereby improving market access and sales channels for farmers. However, this process often involves new intermediaries, such as logistics providers, digital platforms, and payment systems, and depends on factors including digital literacy, internet connectivity, and trust mechanisms like reputation systems and secure payments. Although rural e-commerce can strengthen farmers' market position and increase their income, challenges such as platform fees, logistical costs in remote areas, digital exclusion, and data privacy risks may limit its benefits. To ensure sustainable adoption, complementary investments are necessary in infrastructure (e.g., broadband and transportation), digital skills training, and policies to mitigate the risks associated with platform dependency. The emergence of e-commerce has broken the limitations of geographical space, providing a new avenue for the sales of agricultural products in mountainous rural areas. E-commerce enables numerous buyers and sellers to transcend temporal and spatial constraints, gather on virtual platforms, and generate various real-time information and historical records, forming big data [6,7]. This enhances the accessibility of market information for farmers, largely alleviating the information asymmetry they face [8]. Of course, these points are primarily based on theoretical perspectives.

Can e-commerce improve the sales performance of farmers in practical production, for example, by increasing product sales volume or price? Some scholars have noted that only about 2% of farmers on e-commerce platforms are truly profitable, while 20% to 30% are barely managing to break even, and 50% to 60% are struggling to stay afloat [9]. In response to this phenomenon, researchers analyzing supply chain dynamics have highlighted that rural e-commerce enables smallholder farmers to bypass exploitative intermediary practices, establish direct links with consumers, mitigate market risks, and reduce transaction costs [10–13]. However, some scholars hold the opposite view. Shao [14] believed that the transactional advantages of e-commerce for farmers were gradually being lost due to the rules of the capital market. Nie and Wang [15] also believe that, as e-commerce evolves, the uneven distribution of industrial resources is gradually worsening and the constraints inherent in the rural commercial landscape are becoming more apparent. The combined effect of the domestication of Internet market rules is weakening the connection between farmers and the online marketplace, leading many farmers to withdraw from the online market [16]. Existing research shows that the positive impact of e-commerce on agricultural product sales is not always evident.

There may be two reasons for the heterogeneity found in the above research: Firstly, the environment in which farmers engage in production practice is diverse

and uncertain, and e-commerce may have heterogeneous impacts on the sales of agricultural products for different types of farmers. The generalized evaluation of impact effects may be biased in different samples. Currently, there is limited research on rural farmers in mountainous areas. Secondly, the mechanism of the sales performance improvement effect of e-commerce has not been revealed. Researchers have primarily examined how varying levels of human, physical, and social capital moderate these impacts [4,9,17]. Nonetheless, it is unclear which path e-commerce will affect farmers' sales performance.

Oranges are a representative economic crop grown in the mountainous regions of China. They are also very suitable for sale via e-commerce channels due to their resistance to storage and ease of transportation. Drawing on survey data from rural mountainous areas in Hubei, China, this study uses an endogenous switching regression model to evaluate the average impact of e-commerce on sales performance within a counterfactual framework. The key contributions of this study include, firstly, selecting mountainous rural orange farmers as a specific and important sample group for empirical research, thereby providing a clearer and more focused perspective. Secondly, this research uses an endogenous switching model to mitigate self-selection bias and the effects of omitted variables and unobserved factors. This significantly reduces the biased estimation of results in terms of both research methods and subjects. Thirdly, this study employs a mediation effect model to examine the mechanisms through which e-commerce affects farmers' sales performance, specifically by mitigating information asymmetry, extending the product value chain, and expanding market scope. This provides valuable insight into the decision-making logic behind farmers' participation in e-commerce.

2. Materials and Methods

2.1.Research Hypothesis

This study presents a comprehensive mechanism involving cost reduction, value addition, and market expansion, based on three theories: the information asymmetry theory, the smile curve theory, and the market expansion theory. These theories explain how e-commerce can enhance the sales performance of orange farmers in various ways. The theory of information asymmetry clarifies how e-commerce reduces transaction costs and helps orange farmers obtain fairer prices by providing access to market information. The smile curve theory explains how e-commerce enables orange farmers to participate directly in high-value brand marketing and after-sales services, thereby increasing revenue per unit sold. The market expansion theory suggests that e-commerce overcomes geographical limitations, increasing sales coverage and thereby boosting sales volume. Overall, e-commerce increases the selling price of agricultural products and enhances market efficiency and sales volume [16].

Firstly, according to the theory of incomplete information, particularly with regard to information asymmetry, traditional offline channels for selling oranges are subject to spatial constraints, resulting in fragmented and inadequate market information. While intermediaries can mitigate this issue to some extent by aggregating and disseminating market data, their involvement often comes at a cost, such as lower procurement prices for farmers [18]. Due to information asymmetry, farmers are unable to accurately assess the overall market demand. This leads many farmers to make production decisions based on past agricultural sales conditions and experiences. This results in a surplus of products before demand, causing substantial overproduction. Ultimately, farmers are forced to sell large quantities at prices below production costs, which has a significant impact on their sales performance [19]. E-commerce enables a multitude of buyers and sellers to transcend temporal and spatial limitations, congregating on virtual platforms to generate real-time and historical information, forming big data [6]. This enhances farmers' access to market information, largely breaking the information asymmetry dilemma they face. With access to more market information, such as production factors, product prices, potential traders, and new technologies [20], farmers can better understand the aggregate and heterogeneous demands of consumers, effectively matching supply and demand. This rich

information also provides farmers with bargaining power, thus increasing product selling prices [16].

Secondly, according to the "Smile Curve" theory [21], e-commerce can extend the orange industry by bringing high-value activities in-house at both ends of the supply chain. In the pre-production phase, this may include varietal development and quality certification, while post-production activities may include branding, packaging, marketing, and customer support services (e.g., traceability systems). By integrating functions such as standardized classification, premium packaging, and direct-to-consumer brand sales, e-commerce enhances product differentiation. It captures greater market value, thereby shifting revenue streams away from traditional, low-value intermediary processing segments [1].

Thirdly, e-commerce enables agricultural producers to expand their market scope by developing online distribution channels in addition to traditional offline channels [22]. Unlike offline markets, which are geographically constrained, e-commerce platforms can aggregate nationwide demand for oranges in a unified digital marketplace. This overcomes spatial limitations and expands the market scope from local to national or even global levels. This expansion of channels (supported by digital payment systems, logistics networks, and platform visibility) improves market access efficiency and increases sales volume [23]. However, these benefits may be distributed unevenly due to varying levels of internet access, digital literacy, and trust in online transactions among farmers [24].

Based on the above analysis, we infer the research hypothesis: E-commerce has a beneficial influence on sales performance by mitigating information asymmetry, extending the product value chain, and expanding market scope (**Figure 1**). These can help farmers sell products at higher prices and in larger quantities, thereby improving the agricultural sales performance of mountainous rural farmers.

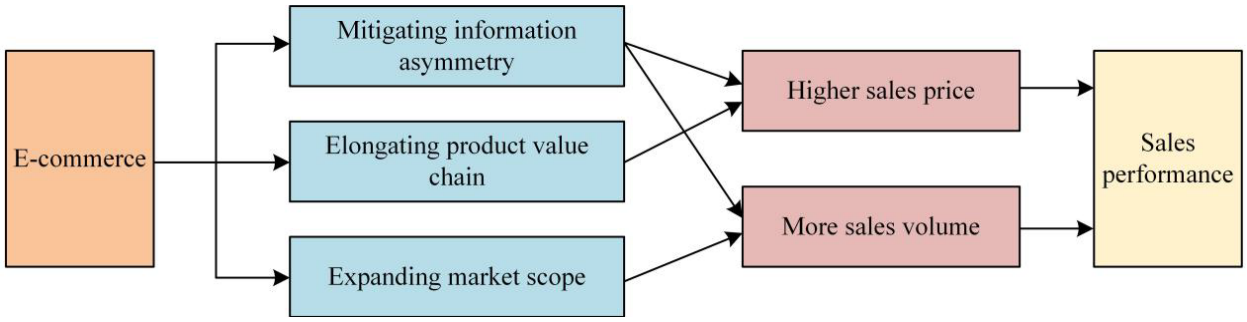

Figure 1. Analytical framework.

2.2.Model

Let E_i = 1 denotes farmers' participation in e-commerce, and E_i = 0 is not. The function for sales performance can be represented as Equation (1):

$$Y_i = \beta X_i + \gamma E_i + \varepsilon_i \quad (1)$$

In Equation (1), Y_i is the sales performance, X_i denotes other factors influencing sales performance, while and are the coefficients. This study utilized the endogenous switching regression (ESR) model to evaluate the processing effect of e-commerce on sales performance [25]. ESR not only considers self-selection bias and endogeneity issues arising from unobservable factors, but it also allows for the correction of specification bias or omitted variable problems in both the choice equation and the result equation by incorporating the inverse Mills ratio. It enables counterfactual analysis by employing complete information maximum likelihood estimation, thus circumventing the issue of missing informative data within the model. Specifically, the ESR model simultaneously estimates the following three Equations (2), (3), and (4):

Choice behavior (whether to participate in e-commerce):

$$E_i = \varphi X_i + \tau I_i + \mu_i \quad (2)$$

Result one:

$$Y_{ia} = \beta_a X_{ia} + \varepsilon_{ia} \quad (3)$$

Result two:

$$Y_{in} = \beta_n X_{in} + \varepsilon_{in} \quad (4)$$

In Equation (2), X_i are factors influencing farmers e-commerce participation. I_i is the instrumental variable vector to ensure the identifiability of the ESR. This study selected "whether there is Wi-Fi in farmers' homes" as an instrumental variable, which only affects farmers' e-commerce participation decisions and does not directly affect sales performance. In Equations (3) and (4), Y_{ia} and Y_{in} respectively represent the sales performance of the farmers who participated or not participated in e-commerce. X_{ia} and X_{in} are a series of factors affecting farmers' sales performance.

This study utilized a counterfactual analysis framework to estimate the average treatment effect, using the difference in sales performance between the actual situation faced by farmers and the hypothetical scenario under the counterfactual assumption.

Average expected sales performance of participating e-commerce samples Equations (5):

$$E\left[Y_{ia} \middle| E_i = 1\right] = \beta_a X_{ia} + \sigma_{ua}\omega_{ia} \quad (5)$$

Average expected sales performance of not participating e-commerce samples Equations (6):

$$E\left[Y_{in} \middle| E_i = 0\right] = \beta_n X_{in} + \sigma_{un}\omega_{in} \quad (6)$$

Assuming that farmers who have already participated in e-commerce no longer participate Equations (7):

$$E\left[Y_{in} \middle| E_i = 1\right] = \beta_n X_{ia} + \sigma_{un}\omega_{ia} \quad (7)$$

Assuming that farmers who have not participated in e-commerce before, in the context of participation Equations (8):

$$E\left[Y_{ia} \middle| E_i = 0\right] = \beta_a X_{in} + \sigma_{ua}\omega_{in} \quad (8)$$

Based on the analysis above, for farmers who have participated in e-commerce, the Average Treatment effect on the Treated (ATT) [Equations (9)]can be represented as the difference between Equations (5) and (7):

$$ATT_i = E[Y_{ia} \mid E_i = 1] - E[Y_{in} \mid E_i = 1] = (\beta_a - \beta_n)X_{ia} + (\sigma_{ua} - \sigma_{un})\omega_{ia} \quad (9)$$

Similarly, for farmers who have not participated in e-commerce before, the Average Treatment effect on the Untreated (ATU) [Equations (10)] is the difference between Equations (6) and (8):

$$ATU_i = E[Y_{in} \mid E_i = 0] - E[Y_{ia} \mid E_i = 0] = (\beta_n - \beta_a)X_{in} + (\sigma_{un} - \sigma_{ua})\omega_{in} \quad (10)$$

Then, mediating effect between e-commerce and sales performance will be examined following the methods proposed by Baron and Kenny [26], Wen and Ye [27]. It consists of three specific steps [Equations (11), (12), and (13)]:

$$Y_i = \beta_0 + \beta_1 E_i + \beta_2 X_i + \varepsilon_i \quad (11)$$

$$M_i = \alpha_0 + \alpha_1 E_i + \alpha_2 X_i + \varepsilon_i \quad (12)$$

$$Y_i = \theta_0 + \theta_1 E_i + \theta_2 M_i + \beta_3 X_i + \varepsilon_i \quad (13)$$

In Equations (11) and (13), Y_i represents sales performance. In Equations (11), (12), and (13), E_i indicate e-commerce participation, and M_i represents the mediating variable in Equations (12) and (13).

2.3.Data

The research dataset was obtained through a comprehensive survey of citrus cultivators in Ziguixian, Hubei Province, China, conducted by the research team in July 2023. Ziguixian is a well-known orange production base in China with a large scale of cultivation, renowned as the "hometown of navel orange". Ziguixian navel oranges are highly favored in domestic and international markets and have been recognized as a Chinese geographical indication product. In addition, due to the unique characteristics of oranges, such as their resistance to storage and ease of transportation, their e-commerce development has become very mature. Importantly, Ziguixian has the advantage of being a major producer of oranges, and e-commerce has significantly assisted orange farmers in sales in recent years. Therefore, the selection of this region is very classic and representative in China. The research team randomly selected two townships, Guojiaba and Shuitianba, from the four largest orange production areas in Ziguixian, and then selected 5–6 villages from each township. Based on the principle of random stratified sampling at the village level, 30–40 orange growers were selected as interviewees in each village. Of course, in order to eliminate the interference of subjective factors in the research and ensure the randomness and representativeness of the sampling. The research team has requested

that the village chief of each village to provide a list of villagers in advance. Subsequently, based on the villagers' serial numbers, sample farmers were selected using an equidistant method (taking samples every 5 names). Before starting to fill out the questionnaire, we read out the ethics approval results of the survey to the respondents. The content of the interview will be recorded in writing, which has also been approved by the farmers. A total of 420 questionnaires were distributed in this survey. After discarding questionnaires with logical errors, numerous blank answers, and unclear handwriting, 406 valid questionnaires were obtained, with an effective response rate of 96.67%. This study was approved by the Ethics Committee of Wuhan Institute of Technology (approval number: wit20221109), the interviewee were consented by an informedconsent process that was reviewed by the Ethics Committee of Wuhan Institute of Technology and certify that the study was performed in accordancewith the ethical standards as laid down in the 1964 Declaration of Helsinki.

2.4.Variable Definition and Descriptive Analysis

2.4.1. Sales Performance

Theoretical analysis shows that e-commerce can increase the sales volume and prices of agricultural products. Therefore, the total income from orange sales, calculated by multiplying the sales volume by the price, is a comprehensive measure of sales performance.

2.4.2. E-Commerce

According to the survey findings, citrus producers predominantly engage with e-commerce platforms via two distinct operational models. The survey reveals a clear pattern of distribution in the adoption of e-commerce among citrus producers, with third-party platforms and WeChat-based commerce representing 13.15% and 86.85% of digital sales channels, respectively. Empirical data demonstrate that farmers utilize a range of online marketing strategies, rather than relying solely on a single distribution method. Nevertheless, the overall penetration rate of digital commerce remains low, with only 37.44% of surveyed agricultural operators engaging in online transactions for citrus fruit.

2.4.3. Other Variables

We selected several personal, family, and environmental characteristics as control variables [4,28,29]. Personal characteristic variables include gender, age, and education. Family characteristic variables include household size, land size, village cadres, entrepreneurial experience, and cooperatives. Environmental characteristic variables include policy, training, logistics, and traffic (**Table 1**).

Table 1. Descriptive statistical of variables.

Variables	Definition	AVE	S.D.
Sales performance	Total income of orange sold (yuan)	10.718	0.917
E-commerce	Whether the farmer sold orange via the Internet: Yes=1, No=0	0.377	0.485
Sex	The gender of the interviewee: Male=1, Female=0	0.579	0.514
Age	The age of the interviewee	49.475	12.096
Education	Education level of the interviewee	1.659	0.785
Household size	Number of the family members	3.892	0.985
Land size	Orange planting area (ha)	0.476	1.656
Village cadre	Whether there are village cadres in the family: Yes=1, No=0	0.047	0.211
Entrepreneur experience	Whether family members have experience in entrepreneurship: Yes=1, No=0	0.084	0.278
Cooperatives	Whether the household participates in a cooperative: Yes=1, No=0	0.392	0.489
Policy	Did you get the relevant financial support policies: Yes=1, No=0	0.384	0.487
Train	Have you received e-commerce training: Yes=1, No=0	0.251	0.434
Logistics	Whether there is an express station in the village: Yes=1, No=0	0.687	0.464
Traffic	Village transportation level: Poor=1, Average=2, Good=3	2.037	0.835
Wi-Fi	Is there Wi-Fi access at home: Yes=1, No=0	0.561	0.324

3. Results and Discussion

3.1.The Results of Simultaneous Equation Estimation

Based on Equations (2)–(4), the simultaneous estimation of farmers' participation in e-commerce and sales performance is shown in **Table 2**. It can be observed that the estimated correlation coefficients of both $\rho_{\mu\alpha}^{1}$ and $\rho_{\mu n}^{2}$ have passed the 1% significance test, indicating a sample selection issue exists. Without correction, the estimated results would be biased. The results in the second column of **Table 2** show that age and household size have passed the significance test. Similarly, family members with entrepreneurial experience are more likely to sell agricultural products online. Mainly because entrepreneurial experience can accumulate a certain amount of human and social capital for farmers, and significantly enhances the performance of channel management through e-commerce [30]. The variable of cooperatives passed the 1% significance test. These findings demonstrate significant concordance with prior research conducted by Shi et al. [31]. In the Internet era, where shared cooperation and efficiency are pursued, group cooperation represents a crucial pathway for agricultural producers to engage in digital commerce.

In addition, this study regresses the relationship between e-commerce and sales performance on whether households have Wi-Fi. Empirical results demonstrate that this factor has a substantial influence on e-commerce participation among farmers; however, the variable has a negligible influence on sales performance indicators, with coefficients failing to reach statistical significance. Therefore, it can be considered that the instrumental variable is effective. In **Table 2**, the presence of Wi-Fi variables in households is significant at the 1% statistical level, positively promoting farmers' participation in e-commerce. Wi-Fi serves as a crucial resource for farmers to connect to the internet. Families with Wi-Fi can access more information and develop targeted training initiatives to improve farmers' digital marketing skills.

Table 2. The results of simultaneous equation estimation.

Variables	E-Commerce Participation	Sales Performance	
		Participate	Not Participate
Sex	-0.166 (0.163)	0.043 (0.107)	0.022 (0.084)
Age	-0.070*** (0.010)	0.023*** (0.008)	0.007 (0.006)
Education	0.065 (0.100)	0.045 (0.063)	0.010 (0.061)
Household size	0.165* (0.085)	-0.012 (0.059)	-0.028 (0.042)
Land size	-0.208 (0.314)	1.156*** (0.151)	2.453*** (0.181)
Village cadre	0.392 (0.365)	-0.293 (0.221)	0.087 (0.210)
Entrepreneur experience	0.954*** (0.315)	0.382** (0.158)	0.407** (0.180)
Cooperatives	1.354*** (0.174)	0.103 (0.153)	0.230* (0.118)
Policy	0.061 (0.186)	0.150 (0.117)	-0.158 (0.110)
Train	-0.154 (0.230)	0.147 (0.137)	0.223 (0.140)
Logistics	0.175 (0.206)	0.159* (0.221)	0.278** (0.137)
Traffic	0.487 (0.300)	0.026* (0.128)	0.215* (0.114)
Wi-Fi	0.771*** (0.235)		
Constants	0.753 (0.692)	9.939*** (0.431)	9.229*** (0.381)
$Ln\sigma_{\mu\alpha}^{1}$		-0.363*** (0.083)	
$\rho_{\mu\alpha}^{1}$		1.413*** (0.304)	
$Ln\sigma_{\mu n}^{2}$			-0.510*** (0.056)
$\rho_{\mu n}^{2}$			0.309*** (0.399)
LR	12.76***		
Log likelihood	-500.375		
Sample size	406	152	254

Note: *, * *, and * * * represent significance at the 10%, 5%, and 1% levels, respectively, with standard errors in parentheses.

3.2.The Treatment Effect of E-Commerce on Sales Performance

The estimated marginal effect of e-commerce participation on sales performance is positive, and it passes the significance level test at 1% (**Table 3**). Based on the ATT value, if farmers who have already participated in e-commerce cease their participation, their sales income will decrease by 9.57%. From the ATU value, the empirical analysis reveals significant economic benefits associated with e-commerce adoption among agricultural producers. Specifically, non-participating farmers demonstrate a potential revenue enhancement of 12.47% upon integrating digital marketplace platforms into their sales channels. These findings substantiate the hypothesis that the adoption of electronic commerce effectively facilitates agricultural income growth, with observed revenue increments ranging from 9.57% to 12.47% among citrus producers. The positive price elasticity of e-commerce participation aligns with previous research by Li et al. [13], who reported comparable income effects in their study of digital agricultural markets.

Table 3. Treatment Effect of E-commerce Participation on sales performance.

Sample Farmers	Average Treatment Effect			
	Participate	Not Participate	ATT	ATU
Farmers who have already participated	11.085	10.024	1.061***	
Farmers who have not participated	11.737	10.436		1.301***

Note: * * * represent significance at the 1% levels.

3.3.Heterogeneity Analysis

3.3.1. Treatment Effects of Different E-Commerce

E-commerce can be divided into platform e-commerce (such as Taobao and Jingdong) and social e-commerce (such as WeChat and Weibo). Considering the differences in transaction costs and thresholds for e-commerce participation across various modes, this study further utilizes the endogenous switching regression model to evaluate the treatment effects of participating in platform e-commerce and social e-commerce on sales performance (**Table 4**). The estimation results indicate that the average treatment effects of farmers participating in these two e-commerce platforms are both statistically significant at a 1% level and positive.

The estimated results of ATT show that if farmers participating in the platform or social e-commerce were to cease engaging in e-commerce, the sales income would decrease by 8.58% and 8.93%, respectively. While the results of ATU show that if farmers who are not participating in the platform or social e-commerce were to engage in e-commerce, their sales performance would improve by 4.22% and 12.57%, respectively. It can be observed that engaging in both platform e-commerce and social e-commerce significantly contributes to the sales performance of agricultural products. Social e-commerce shows a relatively higher facilitating effect. One possible reason is that the entry barrier for platform e-commerce is relatively high, leading to some farmers being excluded from the online market [15]. On the other hand, social e-commerce, with its lower entry barriers, has become an important way for rural areas to participate in e-commerce.

Table 4. The treatment effects of different e-commerce.

Type	Sample Farmers	Participate	Not Participate	ATT	ATU
Platform e-commerce	Farmers who have already participated	11.260	10.294	0.966***	
	Farmers who have not participated	10.595	10.166		0.429***
Social e-commerce	Farmers who have already participated	11.084	10.094	0.990***	
	Farmers who have not participated	11.769	10.455		1.314***
Planting scale above average	Farmers who have already participated	11.260	10.294	0.966***	
	Farmers who have not participated	10.595	10.166		0.429***

Table 4. *Cont.*

Type	Sample Farmers	Participate	Not Participate	ATT	ATU
Planting scale below average	Farmers who have already participated	11.084	10.094	0.990***	
	Farmers who have not participated	11.769	10.455		1.314***

Note: * * * represent significance at the 1% levels.

3.3.2. Treatment Effects of Different Planting Scales

The size of the planting area directly affects orange production, with larger yields enhancing farmers' market bargaining power. Therefore, based on the household planting scales, farmers were grouped. Due to the limited sample sizes and to ensure the effectiveness of the analysis, following the approach of Zeng et al. [4], the samples were divided into two groups for comparative analysis: above-average and below-average. According to the average of the estimated results based on ATT and ATU (**Table 4**), the income increase effect for farmers in the "below average" group participating in e-commerce is 1.152, much higher than the 0.6975 for farmers in the "above average" group engaging in e-commerce. This demonstrates the significant heterogeneity of the promotional effect of e-commerce participation on sales performance. Small-scale farmers tend to fare better in participating in e-commerce compared to large-scale farmers, potentially due to the stronger market bargaining power of large-scale farmers and their established sales channels, while scattered smallholder farmers have been at a disadvantage in the market. The advancement of digital commerce in rural areas has created alternative distribution channels for small-scale agricultural producers, enabling them to bypass traditional intermediary structures.

3.4.The Mechanism of E-Commerce Affects Sales Performance

Drawing upon prior analytical findings, e-commerce primarily affects agricultural sales performance through three distinct mechanisms: Mitigating information asymmetry, extending the product value chain, and expanding market scope. Drawing on the research of several scholars [4,8,11,15], we used the following scale items to measure these three mechanism variables (**Table 5**).

Table 5. The measurement of intermediary variables.

Variables	Measurement Items
Mitigating information asymmetry	Do you know market supply and demand information? (Yes=1, No=0)
	Do you know the real-time market price? (Yes=1, No=0)
	Do you know product quality grading on the market? (Yes=1, No=0)
	Do you know the sales environment of the market? (Yes=1, No=0)
Extending product value chain	Whether products are graded? (Yes=1, No=0)
	Whether products are processed? (Yes=1, No=0)
	Whether self-packaging is done? (Yes=1, No=0)
	Whether sales are conducted online? (Yes=1, No=0)
	Whether after-sales service is provided? (Yes=1, No=0)
Expanding market scope	The number of provinces (cities) where households sell orange.

Note: Mitigating information asymmetry and extending the product value chain are measured using 4 and 5 dummy variable items, respectively, and the variable values are obtained by summing them up.

The results show that e-commerce significantly affects mitigating information asymmetry (**Table 6**). Even after controlling for the effect of e-commerce in column (2), the mitigating information asymmetry still passes the significance test, indicating that the mediating effect exists and is a partial effect. These results align with the empirical evidence reported in Li et al. [13], that e-commerce participation can mitigate information asymmetry and thereby promote sales performance for farmers.

Similarly, the results show that e-commerce has a significant impact on the elongation product value

chain. column (4) shows that after controlling for the effect of e-commerce participation variables, the elongation of the product value chain still has a significant promoting effect on sales performance. From the significance of the estimated values of each variable parameter, it can be seen that the mediating effect of the elongation product value chain exists, and it is a partial mediating effect. These results align with the empirical evidence reported in Feng [22], which suggests that e-commerce participation can extend the agricultural product industry chain, promote value chain upgrading, and thereby enhance sales performance for farmers.

The e-commerce has significantly expanded the market scope. In column (6), after controlling for the impact of e-commerce participation, the mediating variable of expanding market scope still has a significantly positive effect on sales performance. From the significance of the estimated values of each variable parameter, it is obvious that the mediating effect of expanding the market scope exists, also being a partial mediating effect. These results align with the empirical evidence reported in Sarkar et al. [32], which suggests that e-commerce can expand market scope and thereby promote farmers' sales performance.

Table 6. Results of the impact mechanism.

Variables	Mitigating Information Asymmetry		Extending Product Value Chain		Expanding Market Scope	
	(1)	(2)	(3)	(4)	(5)	(6)
E-commerce	0.706*** (0.156)	0.300*** (0.090)	0.839*** (0.141)	0.257*** (0.091)	0.827*** (0.179)	0.281*** (0.089)
Industrial chain				0.077** (0.031)		
Information asymmetry		0.031* (0.028)				
Market scope						0.049** (0.025)
Sex	0.304** (0.118)	0.033 (0.066)	0.214** (0.107)	0.026 (0.066)	0.318** (0.135)	0.027 (0.066)
Age	-0.022*** (0.007)	-0.003 (0.004)	-0.006 (0.006)	-0.003 (0.004)	-0.007 (0.008)	-0.003 (0.004)
Education	0.361*** (0.079)	0.053 (0.045)	0.098 (0.072)	0.057 (0.044)	0.039 (0.091)	0.062 (0.044)
Household size	-0.038 (0.059)	0.031 (0.033)	0.013 (0.053)	0.028 (0.033)	-0.069 (0.068)	0.033 (0.033)
Land size	-0.023 (0.202)	1.635*** (0.113)	-0.443** (0.183)	1.668*** (0.113)	0.008 (0.232)	1.634*** (0.112)
Village cadre	-0.344 (0.272)	-0.124 (0.152)	-0.053 (0.246)	-0.131 (0.151)	-0.317 (0.312)	-0.119 (0.152)
Entrepreneur experience	0.242 (0.205)	-0.230** (0.115)	0.295 (0.186)	-0.245** (0.114)	0.157 (0.235)	-0.230** (0.114)
Cooperatives	-0.016 (0.139)	0.170** (0.078)	-0.014 (0.126)	0.170** (0.077)	-0.287* (0.159)	0.183** (0.078)
policy	0.283* (0.147)	0.004 (0.082)	0.382*** (0.133)	-0.017 (0.082)	0.350** (0.168)	-0.005 (0.082)
train	0.129 (0.177)	0.194* (0.099)	-0.183 (0.160)	0.212** (0.099)	-0.126 (0.203)	0.204** (0.099)
Logistics	0.019 (0.201)	-0.174 (0.112)	0.279 (0.182)	-0.195* (0.112)	0.583** (0.231)	-0.202* (0.113)
Traffic	0.004 (0.153)	0.186** (0.086)	-0.097 (0.139)	0.194** (0.085)	-0.272 (0.176)	0.200** (0.086)
F-test	13.110***	28.461***	9.202***	29.185***	5.149***	28.861***
R-squared	0.304	0.505	0.234	0.512	0.146	0.509

Note: *, * *, and * * * represent significance at the 10%, 5%, and 1% levels, respectively, with standard errors in parentheses.

This study employs the Bootstrapping method (repeated 5000 times with a 95% confidence level) to verify the mediating effects of mitigating information asymmetry, extending the product value chain, and expanding market scope. The direct effect of e-commerce on sales performance through mitigating information asymmetry is 0.335, with an indirect effect of 0.066 and a CI statistic of 0.002 and 0.135, excluding 0 (**Table 7**). This indicates that mitigating information asymmetry partially mediates the relationship between e-commerce participation and sales performance. Similarly, it can be concluded that extending the product value chain and the market scope also moderate the association between e-commerce and sales performance.

Table 7. Robustness test results.

Intermediary Model	Total Effect	Direct Effect	Indirect Effect [95% CI]
E-commerce → Mitigating information asymmetry → Sales performance	0.401	0.335***	0.066**[0.002, 0.135]
E-commerce → Extending product value chain → Sales performance	0.367	0.289***	0.078***[0.028, 0.136]
E-commerce → Expanding market scope → Sales performance	0.314	0.273***	0.041**[0.001, 0.084]

Note: * * and * * * represent significance at the 5% and 1% levels, respectively.

4. Conclusion and Implications

This study examines the impact of e-commerce on sales performance using survey data from 406 orange growers in the mountainous, rural region of Hubei Province in China. We also analyzed and validated the mechanism through which e-commerce participation improves sales performance using an intermediary effect model. Our findings are as follows: Firstly, e-commerce participation significantly improves agricultural sales performance. Secondly, social e-commerce is more effective than platform e-commerce and has a greater impact on smallholder farmers than on large-scale farmers. Thirdly, e-commerce can enhance sales performance by mitigating information asymmetry, extending the product value chain, and broadening the market scope.

This study integrates three theoretical perspectives—information asymmetry theory, smile curve theory, and market expansion theory—to construct a comprehensive framework that explains how e-commerce can enhance farmers' sales performance. This provides new analytical insights into the distribution of agricultural products in the digital economy. The findings reveal that social commerce has a powerful effect on smallholder farmers. This suggests that relationship-based e-commerce models are better suited to the characteristics of rural markets in developing countries. There are also direct implications for platform optimization, such as simplified interfaces and enhanced community features. From a societal perspective, although e-commerce adoption can increase rural incomes and support rural revitalization, it may also exacerbate disparities due to the digital divide. Complementary policies are therefore needed to ensure inclusive development, including strengthening rural digital infrastructure to provide basic access, offering differentiated training (e.g., guidance on operating in social commerce for smallholders), and encouraging leading enterprises to foster industrial agglomeration. Collectively, these theoretical and practical implications demonstrate that e-commerce-enabled agricultural development requires a "dual-drive" approach, combining technological empowerment with institutional safeguards—leveraging market mechanisms while implementing targeted interventions to bridge the digital divide—to achieve truly inclusive growth.

5. Limitation

The sample of this study, reveals a significant positive impact of e-commerce on the sales performance of

orange farmers in mountainous areas, providing a practical reference for e-commerce agricultural assistance actions in some regions worldwide. Of course, this study may also have limitations in the following areas: Firstly, this study places significant emphasis on the benefits of e-commerce, while failing to acknowledge potential challenges or limitations, including the digital divide, infrastructure gaps, and the capabilities of farmers [3,12]. In practice, many low-integrity farmers lack the capacity to participate in e-commerce [18]. These factors are antecedents to this study and require further investigation through more in-depth practice cases and data analysis. Secondly, this study may be limited to the main orange-producing areas in Hubei Province, China, so regional heterogeneity needs to be considered in the practical application of the results. Although the subject group used scientific sampling methods as much as possible to standardize the issue of sample representativeness. However, the environment developing agricultural e-commerce in China, and even in different regions of the world, is quite different. Different sample studies may even bring opposite conclusions [13]. Of course, we cannot therefore ignore the sample conclusions of different typical regions.

Author Contributions

Conceptualization, D.L. and Y.H.; methodology, D.L.; software, Y.H.; validation, D.L., A.L. and Y.H.; formal analysis, Y.H.; investigation, D.L. and Y.H.; resources, Y.H.; data curation, A.L.; writing—original draft preparation, D.L.; writing—review and editing, D.L.; visualization, A.L.; supervision, D.L. and Y.H.; project administration, D.L. and Y.H.; funding acquisition, Y.H. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Wuhan Institute of Technology (protocol code: wit20221109, dated June 20, 2022).

Informed Consent Statement

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

Data Availability Statement

The research data can be found through the following link: https://data.mendeley.com/preview/bbw3frgbh6

Conflicts of Interest

The authors declare that they have no conflict of interest.

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