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What Are the Effects of Participation in Production Outsourcing? Evidence from Chinese Apple Farmers

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Abstract: Outsourcing, as a productive service, has been widely adopted in industrial production and international trade but less applied in agricultural management. With the advancement of agricultural labor division and specialization, outsourcing is becoming one of the most sustained trends in concurrent business. This study used a multiple linear regression and a propensity score matching model to quantify the different effects of participation in production outsourcing on farmers' apple production efficiency and apple income based on field survey data from 960 apple farmers in the Shandong, Shaanxi, and Gansu Provinces. The results showed that, on average, the outsourcing of apple production increased farmers' apple production technology efficiency by 5.60%, their labor productivity by 2121.48 kg/person, land productivity by 334.50 kg/mu, capital productivity by 0.05 kg/Yuan, and apple sales revenue by 13,300 Yuan. However, farmers' net income from apples decreased by an average of 5000 Yuan. The outsourcing of apple production, which is labor-intensive, is constrained by the increase in labor costs, which, in turn, affect the transformation of the apple industry into a service-scale operation driven by the economy of division.

Keywords: production outsourcing; production efficiency; propensity score matching; apple farmers; China

1. Introduction

Agriculture is a fundamental industry that is playing an increasingly important role in the national economy and in people's livelihoods [1]. The modernization and sustainability of agriculture and rural areas are also keys to the realization of national modernization and prosperity [2]. In particular, scale management, as the foundation of agricultural modernization [3], has received extensive attention in political and academic circles.

From a policy perspective, various forms of moderate scale management have been developed to achieve the organic connection between small farmers and modern agricultural development. In Sub-Saharan Africa, public–private partnerships for an agricultural development project are an effective approach to achieve the modernization of agricultural development [4]. Contract farming, as a sale arrangement between farmers and firms, has been promoted by the government in many developing countries [5]. From an academic research perspective, scholars have focused on the developmental path and the mode of agricultural scale management. Some scholars think that the trend of "part-time" and "off-farm" labor, caused by the transfer of agricultural labor, promotes the concentration of rural land and the processes of industrialization and urbanization and that this process is conducive to the realization of agricultural scale operations [6–9]; however, the decentralized operation of small farmers is still the basic organizational form of agricultural production and management at this stage in China. There are nearly 260 million farmers in China whose scale of land management was below 50 mu at the end of 2016, accounting for 97% of the total number

of farmers. The average area of cultivated land was approximately 5 acres. Although land transfer has alleviated the problem of scale management to a certain extent, the overall promotion is slow, and the developmental path of land scale management based on land logic is limited [10–12]. Therefore, the exploration of other paths to achieve scaled operations is particularly important for agricultural modernization.

According to the principle of division of labor, some researchers have suggested that, on the basis of family management, the transformation from a land-scale operation to a service-scale operation through socialized services, such as agricultural production outsourcing, is important for innovation in agricultural management methods [13,14]. In essence, the separability of agricultural activities and the outsourcing of services have increased the possibility of family business involvement in the social division of labor. Family management and service organizations share the cooperative surplus by increasing their efficiency through specialization and the division of labor. In this context, the scale of agriculture is ultimately expressed as the division of labor [15,16].

Outsourcing is currently being adopted both domestically and internationally, such as business process outsourcing [17] and offshore outsourcing [18]. Many researchers across different disciplines have investigated outsourcing mechanisms, welfare effects, and the determining factors that affect farmers' participation behaviors in agriculture outsourcing. Regarding outsourcing mechanisms, most studies have been designed to explain the economic implications of agricultural production outsourcing based on resource-based theory and transaction cost theory. Family resource endowment constraints and lower transaction costs are both important factors promoting the outsourcing of agricultural production [18–23]. Studies on the welfare effects of outsourcing have confirmed that the outsourcing of agricultural production can reduce production costs and improve production efficiency [24–26], strengthen the specialized division of labor and promote agricultural scale operations [27], and improve the degree of organization of agricultural production [28]. The available research has theoretically analyzed and empirically tested the decision-making behaviors of farmers with respect to agricultural production outsourcing using behavior choice theory, the production function model, and the property rights theory from the perspectives of the differentiation of farmers' roles [29], the differences in cultivation scale [30], the differences in the attributes of production links [31], and transaction characteristics and the capacity for subjective behavior [27,32].

In summary, the results of multi-perspective research have laid a rich foundation for this study, but the existing research has the following limitations. First, the research focus has been mainly rice, wheat, and other grain growers; studies of cash crops are lacking. As a perennial and high-value economic crop, apples have clear differences in outsourcing from in comparison to the other crops: the apple industry is a labor-intensive industry, and its outsourcing is still dependent on employees because of the lower degree of mechanization compared with grain production. Thus, the study of outsourcing in apple production is significant for the construction of a productive service system in the apple industry. Second, the research methods have generally used traditional regression models, such as logistic and probit models, which do not address the self-selection problem that may be caused by heterogeneity resulting from the causal relationship between outsourcing and farmer welfare. Therefore, we used the propensity score matching (PSM) model to reduce the impact of potential problems based on the framework of counterfactual analysis and expand the empirical methods of the existing research. Third, although these studies partially explained farmers' decision-making mechanisms for outsourcing behaviors, the effects of outsourcing on farmers have been, to date, largely neglected, particularly the effects on agricultural production efficiency and income. A few researchers have expressed concern about the influence of outsourcing on farmers' production efficiency, but these studies did not consider the impact on farmers' agricultural income. Increasing farmers' income is the ultimate goal of agricultural production. Outsourcing, as a productive service, aims to improve agricultural production efficiency through specialization and the division of labor and ultimately increase farmer income. Therefore, this study attempts to contribute to the literature by examining how outsourcing influences farmers' agricultural production efficiency and agricultural income.

This study focuses on the relationship between apple production outsourcing and apple production efficiency (e.g., technology efficiency, labor productivity, land productivity, and capital productivity) and apple income (e.g., apple sales revenue and apple net profit). Based on micro-survey data from 960 apple farmers in Shandong, Shaanxi, and Gansu Provinces in China, multiple linear regression (MLR) and PSM models were used to comprehensively examine the influence of outsourcing on farmers' apple production efficiency and income and to explore the actual effect of apple production outsourcing. From an apple farmer perspective, apple production usually entails more labor-related investment, implying that outsourcing might be more complex and available. Clarification of the impact of outsourcing activities on apple production will contribute toward understanding the mechanisms, functions, and efficiency of a general socialized service system in China.

The remainder of this study is structured as follows. Section 2 outlines the analysis framework and the corresponding model design. Section 3 provides the data sources and descriptive statistics for the characteristic differences between participants and non-participants within specialized apple production sites. Section 4 discusses the empirical results by estimating the determinants of outsourcing participation and assessing the welfare effects of outsourcing behavior on apple farmers. Section 5 outlines the conclusion and policy implications.

2. Conceptual Framework and Estimation Strategies

2.1. Conceptual Framework

Since the publication of the *Wealth of Nations* by Adam Smith in 1776, the division and specialization of labor have gradually attracted the attention of economists. Academia generally thinks that the division and specialization of labor are the key to increasing marginal returns [33], which is the source of economic growth, and can improve production efficiency [34]. The outsourcing of agricultural production has emerged in the deepening of a specialized division of labor, the continuous advancement of technological innovation, and the increasing shortage of agricultural labor. Outsourcing takes the form of the separation of different production links or functions among different farmers in the process of agricultural production. The new transition of scale operations from land logic to division logic is the embodiment of the specialization and division of labor, the purpose of which is to increase agricultural income by improving agricultural production efficiency. This study defines the outsourcing of apple production links as a management behavior where apple farmers with land management rights pay service fees to an individual or organization to complete one or more production tasks in order to increase apple productivity and income or reduce the opportunity cost of farming.

Specifically, according to resource-based theory and comparative advantage theory, a resource that is influenced by the scarcity and heterogeneity of agricultural production resources promotes the outsourcing of agricultural production links among farmers. Depending on the comparative advantage of the family, apple farmers who are rational economic agents comprehensively consider and determine whether to participate in the outsourcing of apple production links based on the household resource endowment and external environmental conditions. Based on these considerations, apple farmers reconfigure domestic resources and external resources and change the combination of production inputs, such as labor, capital, land, and technology, to directly affect productivity. Some studies have shown that the outsourcing of agricultural production significantly improves agricultural production efficiency [24,25]. The outsourcing of apple production can effectively compensate for a shortage in the quantity and skills of apple farmers' agricultural labor, and the effects of reorganization and technology spillovers can increase apple farmers' productivity. Therefore, participating in outsourcing of apple production links can improve apple production efficiency.

As the degree of specialization of apple production continues to increase, the division of labor will promote a more rational combination of production factors and increase apple production efficiency and the marginal production of production factors. The increase in apple production directly promotes

an increase in farmers' income when the market price of apples is fixed. Therefore, participating in the outsourcing of apple production links can increase household apple income. Based on the above analysis, the conceptual framework of this study can be expressed as shown in Figure 1.
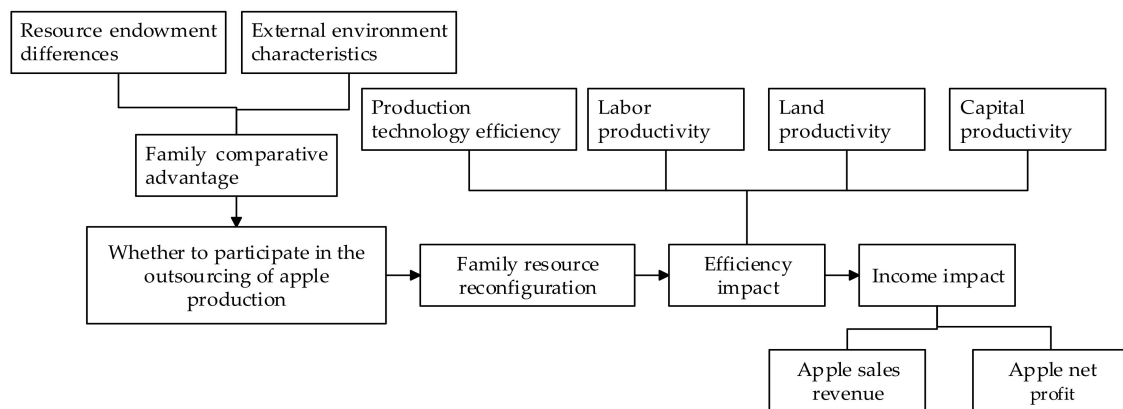

Figure 1. Conceptual framework for the outsourcing behavior of apple farmers.

2.2. Estimation Strategies

Based on the approach of Xu et al. [35], this study uses both the multiple linear regression (MLR) and PSM models and compares the similarities and differences in the results from these two models.

The MLR model assumes that there is no heterogeneity among farmers. To evaluate the effect of the apple farmers' participation in the outsourcing of apple production, we first assumed that there is no heterogeneity between participants and non-participants in the outsourcing of apple production. Specifically, the impact of outsourcing on the farmers' apple production efficiency and income was estimated using a MLR model. The specified model is:

$$Y_i = \beta_0 + \alpha \times Outsourcing_i + \beta \times X_i + e_i \tag{1}$$

where Y_i is the dependent variable that represents the apple production efficiency or income, $Outsourcing_i$ is the observed binary variable that takes the value 1 for outsourcing participants and 0 for non-participants, X_i is a vector of other explanatory variables that affect the apple production efficiency and income, β_0 is the intercept term, e_i is an error term, and α and β are the vectors of the parameters to be estimated.

The PSM model assumes that there is heterogeneity among farmers. In the case of heterogeneity between participants and non-participants in the outsourcing of apple production, the PSM model was used to compare apple production efficiency and income differences between participants and non-participants. The decision of farmers to participate in the outsourcing of apple production is the result of self-selection; the apple farmers who have more labor engaged in apple production and a high degree of concurrent business do not need to outsource, but most farmers involved in the outsourcing of apple production usually have a high level of education, many years of apple planting experience, and a large scale of apple planting [36]. Outsourcing participants and non-participants are clearly different in their individual, household, and apple production characteristics, mainly occur because farmers decide whether to participate in outsourcing by themselves (self-selection). The farmers' outsourcing participation decisions are most likely influenced by observable factors (e.g., education, growing experience, and planting scale) that may be correlated with the outcome (apple production efficiency and income, in this case). This correlation influences the sample selection, which must be determined to obtain an unbiased and consistent estimation of the treatment effect of outsourcing participation on the apple production efficiency and income. The econometric technique used to deal with selection bias in the case of a continuous outcome variable (here, the apple production efficiency and the income status of apple farmers) was the propensity score matching (PSM) model.

Notably, based on the Rubin's counterfactual framework, the PSM model can address the problem of selection bias and biased estimation caused by self-selection in the process of outsourcing decision-making. The PSM model enables the correction of the implicit problem of self-selection in the sample by using the matching method, and it relaxes the assumptions of the function form, parameter constraints, and error term distribution [37]. For these reasons, we used the PSM model to estimate the effects of outsourcing participation on apple production efficiency and income.

In the PSM model, the decision to participate in outsourcing and its impact on apple production efficiency and income can be modeled in a three-stage treatment framework. In the first stage, the decision of farmers to participate in outsourcing was modeled and estimated using a logit model. Following a profit maximization framework, apple farmers decide to participate in outsourcing if the profits gained from the participation are greater than non-participation. Thus, the decision to participate in outsourcing for apple farmers can be presented in a discrete choice model. The logit model was used to estimate the conditional probability fitted value (namely, the propensity score) of each farmer's participation in outsourcing under the given pretreatment characteristics. The specified model is:

$$p(X_i) = P_r[D = 1 | X_i] = \frac{\exp(\beta X_i)}{1 + \exp(\beta X_i)} \tag{2}$$

where D is the treatment variable (i.e., the observed binary variable that takes a value of 1 for outsourcing participants and 0 for non-participants), X_i is a multidimensional vector of covariates (e.g., education, growing experience, and planting scale) that may influence apple farmers' participation in the outsourcing of apple production, and p is a vector of the propensity scores to be estimated, which represents the conditional probability of the apple farmer to participate in outsourcing.

In the second stage, the participants and non-participants were matched according to their propensity scores. Because the matching values and weights applied by different matching methods are different, the matching results are different. We used four matching methods (including k-nearest neighbor matching, caliper matching, k-nearest neighbor matching in calipers, and kernel matching) and compared these results (similar to a sensitivity analysis). If the results of the different matching methods are similar, the matching result is robust and does not depend on the specific method.

In the third stage, the average treatment effect on the treated (ATT) was estimated to obtain the effect of participating in outsourcing on apple production efficiency and income. The ATT refers to the expected effect of the treatment on individuals with the observed characteristics X who participate in outsourcing. After correcting the selection bias arising from both the observed and unobserved factors as previously discussed, the ATT estimates were unbiased:

$$ATT = E\left[Y_1^i - Y_0^i\right] = E\left[Y_1^i - Y_0^i | D = 1\right] = E\left[Y_1^i | D = 1\right] - E\left[Y_0^i | D = 0\right] \tag{3}$$

where the outer expectation is over the distribution of $p(X_i | D = 1)$, Y_1^i and Y_0^i are the potential outcomes in the two counterfactual situations of (respectively) participation and no participation, $E\left[Y_1^i | D = 1\right]$ is the expectation of apple production efficiency and income of the participants in an observed context, and $E\left[Y_0^i | D = 1\right]$ is the expectation of apple production efficiency and income of the participants in a counterfactual context. By using the PSM model, we can identify a group of non-participating farmers who have characteristics similar to the participating farmers and observe their apple production efficiency and income to estimate $E\left[Y_0^i | D = 1\right]$. The difference between $E\left[Y_1^i | D = 1\right]$ and $E\left[Y_0^i | D = 1\right]$ is the effect of participation in outsourcing on the farmers' apple productivity and income.

3. Data and Descriptive Statistics

3.1. Data Source and Sampling Methods

The data used in the present study were collected by the China Agriculture Research System (CARS) through a field survey of apple farmers between July and August 2016 in Shaanxi and Gansu Provinces in the Loess Plateau region and in Shandong Province in the Bohai Gulf region (Figure 2). The investigators were first trained, and they then conducted preliminary research to ensure that they accurately understood the questionnaires. Finally, formal interviews were conducted with the farmers. The field survey collected detailed information on the respondents' apple production and operation details as well as organizational participation.
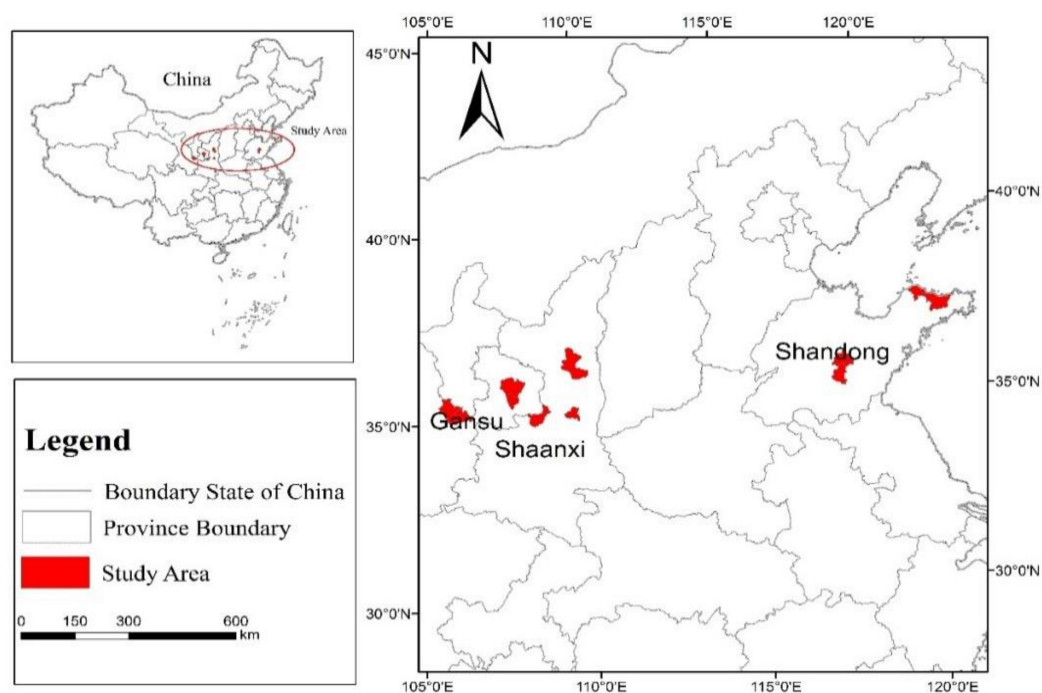

Figure 2. Geographic locations of the sample sites.

A multi-stage sampling procedure was used to select counties and their sub-divisions and farm households. In the first stage, we used the probability proportional to size (PPS) sampling method to select four apple-producing counties in Shandong, four counties in Gansu, and three counties in Shaanxi based on the size of apple production in 2015. In the second stage, eight villages in each selected county were randomly selected. In the third stage, random sampling techniques were used to identify the sample of apple farmers, and approximately 8–12 households in each village were randomly selected. A sample frame acquired from the local apple sector in each selected county was used to sample the required number of farmers from each village. Overall, 11 counties were randomly selected in the three provinces, and 967 sample households were selected for the interview. The questionnaire included household and farm-level characteristics, apple production and operation details, cooperative membership, and outsourcing participation in 2015.

A structured face-to-face questionnaire was conducted with household heads or their spouses who were willing to participate. The collected information was based, as much as possible, on written records; for farmers who did not keep records, information was based on recall data. Some of the interviewed farmers had not sold the apples harvested in 2015, but kept these apples in cold storage. We excluded these farmers from our analyses. Data from 960 farmers, including 686 outsourcing participants (185 in Shaanxi, 236 in Shandong, and 265 in Gansu) and 274 non-participants (67 in Shaanxi, 131 in Shandong, and 76 in Gansu) were used in the analyses.

3.2. Basic Characterization

Based on the conclusions of former studies and the characteristics of apple growing, technology efficiency, labor productivity, land productivity, capital productivity, apple revenue, and apple profit were used as outcome variables. The binary variable of outsourcing (whether to participate in the outsourcing of apple production) was used as a treatment variable, and the individual characteristics of apple production decision makers, household characteristics, apple production characteristics, and external environmental characteristics were used as covariates in this study.

Table 1 presents the definitions and the mean differences in the demographic and statistical characteristics between outsourcing participants and non-participants for the variables used in the present study. There were statistically significant differences at least at the 10% level in the mean value of 13 variables between the two groups. The heterogeneity of outsourcing participants and non-participants was also revealed to some extent. Furthermore, participating in the outsourcing of apple production had a significant positive impact on apple productivity and income. Outsourcing participants were more efficient than non-participants. On average, the per capita apple production and the apple revenue for outsourcing participants were 8304.94 kg/person and 69,799.34 Yuan, respectively, which were higher than their counterparts. The technology efficiency for outsourcing participants was 4.51% higher than for those who do not outsource. Table 1 also demonstrates that, relative to non-participants, outsourcing participants were generally younger and had higher education levels. Outsourcing participants had, on average, fewer apple laborers and a larger acreage (7.94 mu compared with 5.02 mu for non-participants). Theoretical assumptions were indirectly verified. However, this difference does not account for the effect of other farmer characteristics and thus cannot be considered as an ultimate outcome. Therefore, MLR and PSM models were needed to further analyze and confirm the promotion effect of outsourcing on production efficiency and income.

Table 1. Group differences between outsourcing participants and non-participants.

Variables	Definition	Non-Participants	Participants	Mean Difference
Outcome variable				
Technology efficiency	Calculated by stochastic frontier approach	0.60	0.64	0.045 ***
Labor productivity	Apple production per capita in 2015 (kg/person)	4556.59	8304.94	3748.357 ***
Land productivity	Apple productions per mu in 2015 (kg/mu)	2327.89	2348.58	20.695
Capital productivity	Apple productions per capital in 2015 (kg/Yuan)	0.72	0.73	0.013
Apple revenue	Apple sales gross income in 2015 (Yuan)	37,379.17	69,799.34	32,420.174 ***
Apple profit	Household apple net income in 2015 (Yuan)	20,399.41	26,651.40	6251.996 *
Covariate				
Personal characteristics of apple production decision makers				
Sex	Gender: 1 = male; 0 = female	0.93	0.92	−0.010
Age	Actual age in 2015 (years)	52.31	50.37	−1.945 ***
Education	0 = illiteracy; 1 = primary school; 2 = middle school; 3 = high school; 4 = college or above	1.73	1.89	0.161 ***
Organization member	Party members or village cadres: 1 = yes; 0 = no	0.23	0.23	0.006
Cooperative member	1 = yes; 0 = no	0.37	0.37	−0.005
Household characteristics				
Grower number	Total number of apple laborers (number)	2.08	2.00	−0.078 *
Growing experience	Years of apple planting (years)	20.57	20.78	0.206
Concurrent business	Proportion of agricultural income in 2015 (%)	0.77	0.79	0.022
Apple production characteristics				
Planting scale	Apple acreage in 2015 (mu)	5.02	7.94	2.924 ***
Fragmentation degree	Average orchard area per block (mu)	1.28	0.78	−0.503 **
External environment characteristics				
Township distance	Distance from home to the nearest township (km)	13.35	17.86	4.517 **
Hired labor price	Arithmetic mean of the price in each production link (Yuan/workday)	130.24	125.60	−4.637 **
Shandong	1 = yes; 0 = no	0.48	0.34	−0.134 ***
Shaanxi	1 = yes; 0 = no	0.24	0.27	0.025
Gansu	1 = yes; 0 = no	0.28	0.39	0.109 ***

Note: Technology efficiency is the measure of the ability of production units to achieve maximum output under the maximum use of existing technology. It is measured as the ratio between the actual output and the maximum potential output of the unit. We used the stochastic frontier approach (SFA) and the translog production function model [38] to measure the farmers' apple production technology efficiency. The input of the production factors includes labor (the total amount of labor used in apple production by the household in 2015, i.e., the sum of self-employed and employed labor; a standard labor day is the normal amount of work by one middle-aged laborer

in eight hours), land (the household's apple acreage) and capital (the cost of fertilizer, pesticides, fruit bags, and reflective film for apple production of the household in 2015). The output is the total apple output of the household in 2015; 1 mu = 0.06667 hectare, Yuan is the Chinese currency, and 1 Yuan = $0.1442 USD. *, **, and *** indicates significance at the 10, 5, and 1% levels, respectively. The mean difference is between participants and non-participants (participants minus non-participants).

4. Empirical Results

4.1. Regression Analysis of Outsourcing Participation Effect in Apple Production

To demonstrate the effect of participation in outsourcing on apple production efficiency and income, a MLR model calculated using the ordinary least square (OLS) approach was used to estimate Equation (1) without considering the influence of heterogeneity. The results are shown in Table 2. In terms of production efficiency, participating in the outsourcing of apple production improved the technology efficiency of apple production by 5.31%, labor productivity by 2079.99 kg/person, land productivity by 312.81 kg/mu, and capital productivity by 0.03 kg/Yuan, but the effect on capital productivity was not statistically significant. In terms of apple income, participating in the outsourcing of apple production significantly increased farmers' apple revenue by 14,320.75 Yuan, but reduced the farmers' apple net profit by 3840.01 Yuan, although the impact was not statistically significant.

4.2. Determinants of Outsourcing Participation in Apple Production

As indicated previously, the logit model was used to evaluate the participation in outsourcing. There were 686 outsourcing participants and 274 non-participants. The estimates of the determinants of outsourcing participation are presented in Table 3. The explanatory variables selected in this study had a significant impact on the decision-making behavior of outsourcing participation. In particular, age was an important determining factor affecting outsourcing participation; the probability of participating in outsourcing decreased with increasing age. This result is consistent with the findings of Ji et al. [29] for China. Education had a significant and positive impact on the likelihood of participating in outsourcing, which suggests that better-educated apple production decision makers have a significantly higher probability of engaging in outsourcing. This result is consistent with Wang et al. [39], who found that education played an important role in gaining access to machine services.

The number of laborers engaged in apple production in a household and the level of concurrent business were negatively correlated with outsourcing participation and statistically significant, suggesting that the likelihood of outsourcing participation decreases as the number of apple growers and the level of concurrent business in a household increases. The available evidence from China was presented by Ji et al. [29]. An increase in apple growing experience increases the probability of outsourcing participation. This finding is consistent with the results of Chen and Huang [40], who investigated the relationship between farmers' skills and the willingness to outsource, and found that the likelihood of participation in outsourcing was higher in experienced farmers than in inexperienced farmers in China. The apple orchard area had a significant and positive impact on the likelihood of participating in outsourcing, which suggests that larger-scale apple households have a significantly higher probability of engaging in outsourcing, which is consistent with the findings of Ji et al. [29] for China.

Table 2. Estimation results of multiple linear regression models.

Variables	Technology Efficiency	Labor Productivity	Land Productivity	Capital Productivity	Apple Revenue	Apple Profit
Core variable						
Outsourcing	0.0531 ***	2079.9895 ***	312.8094 ***	0.0261	14,320.7500 ***	−3840.0110
Control variables						
Personal characteristics of apple production decision makers						
Sex	0.0075	−209.6380	−116.8471	0.0677 *	3789.1120	10,079.1400 **
Age	−0.0013 **	−5.1766	−7.8067 *	−0.0010	200.9413	15.2144
Education	0.0038	743.2185 ***	28.0121	−0.0136	8609.4760 **	5473.2510 **
Organization member	0.0012	−1433.3385 ***	−202.8282 **	0.0008	−2594.2660	4086.1890
Cooperative member	−0.0036	305.7484	60.7651	0.0134	−3198.0390	−7104.6250
Household characteristics						
Grower number	0.0007	−2776.1155 ***	139.5331 **	0.0086	−5299.2920	−5510.4040
Growing experience	0.0028 ***	−35.5300	11.8895 **	0.0040 ***	−1299.4790 ***	−715.4605 *
Concurrent business	−0.0438	−1525.7250	−446.1875 **	−0.0636	−30,896.4000 **	−23,538.3300 **
Apple production characteristics						
Planting scale	−0.0005	750.5785 ***	−41.2456 ***	−0.0018	8007.4220 ***	3608.4450 ***
Fragmentation degree	−0.0091 *	−148.5191	149.0635 ***	−0.0178	180.1038	−14.5041
External environment characteristics						
Township distance	0.0000	2.9390	0.8344	−0.0000	32.6379	28.5808
Hired labor price	−0.0002	−8.6255	−4.4715 ***	−0.0009 **	47.0112	54.1362
Shandong	0.1189 ***	5028.2500 ***	1475.4555 ***	0.1312 ***	34,804.7600 ***	12,063.5900 **
Shaanxi	−0.0111	−930.7320 *	55.3985	−0.0801 ***	−19,184.8300 ***	−12,687.4100 **
Constant	0.5859 ***	4875.8895 ***	2339.4215 ***	0.7429 ***	−18,468.7000	−318.9363

Note: *, **, and *** indicate significance at the 10, 5, and 1% levels, respectively. The reference region is Gansu.

The location variables were statistically significant, which suggests that, compared with apple farmers in Gansu, apple farmers in Shandong and Shaanxi were less likely to participate in outsourcing. This phenomenon may be explained by the fact that Gansu is a less economically developed province in comparison to Shandong and Shaanxi, and its price for agricultural labor is also lower than the other two provinces (115.65 Yuan/workday in Gansu, 124.64 Yuan/workday in Shaanxi and 138.96 Yuan/workday in Shandong in the survey).

Table 3. Determinants of outsourcing participation.

Explanatory Variable	Estimates	S.E.
Personal characteristics of apple production decision makers		
Sex	−0.1780	0.2853
Age	−0.0197 **	0.0090
Education	0.2193 **	0.0955
Organization member	−0.0461	0.1833
Cooperative member	0.0282	0.1747
Household characteristics		
Grower number	−0.4391 ***	0.1341
Growing experience	0.0220 **	0.0102
Concurrent business	−0.5033 *	0.2737
Apple production characteristics		
Planting scale	0.0478 ***	0.0155
Fragmentation degree	−0.1071	0.0726
External environment characteristics		
Township distance	0.0020	0.0016
Hired labor price	−0.0038	0.0026
Shandong	−0.6439 ***	0.2206
Shaanxi	−0.5411 **	0.2087
Constant	2.8138 ***	0.7179

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

4.3. Matching Quality Inspection

To validate the quality of the matching, it was necessary to further examine the common support domain of the propensity scores. The results are shown in Figures 3 and 4. Most of the observations were within the common range (on support), and only a small number of samples were lost when matching from Figure 3. The results from Figure 4 demonstrate that most of the propensity score intervals of the outsourcing participant and non-participant groups have substantial overlap, i.e., most of the propensity scores are in the common support domain, indicating that this sample met the matching requirements.

A balance test was also used to measure the quality of matching. This test evaluates whether the PSM model satisfies the overlap hypothesis, i.e., there is no systematic difference between the participant group and the non-participant group in each covariate. If the sample matching effect is good, the Pseudo-R^2 value calculated after matching will be very small, and the likelihood ratio test before matching will be rejected, however, after matching is accepted, the difference in the standardized mean (B) will be less than 25%. Table 4 shows the results of the balance test of matching quality. After matching, the Pseudo-R^2 value was nearly reduced to zero, the likelihood ratio test accepted the null hypothesis that the coefficients of the covariates were simultaneously zero, the mean deviation and the median deviation are sharply reduced, and the B value dropped significantly to less than 25%. Generally, these findings validate the applicability of the PSM model.
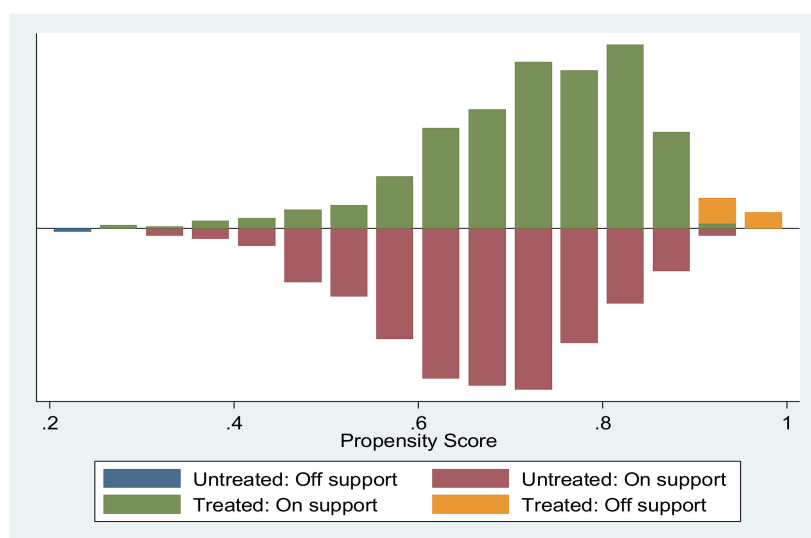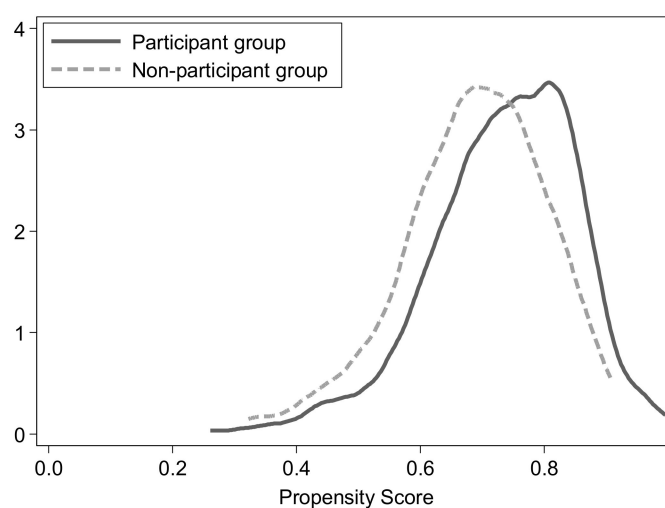
Figure 3. Common range of propensity scores.

Figure 4. Density function of propensity scores.

Table 4. Balance test of matching quality.

Matching Method	Pseudo-R^2	LR chi2	Mean Deviation	Median Deviation	B (%)
Before matching	0.063	72.28 ***	14.4	14.2	61.6+
K-nearest neighbor matching	0.006	10.14	2.8	1.8	17.6
Caliper matching	0.004	6.53	2	1.6	14.2
K-nearest matching in caliper	0.006	11.01	2.7	1.6	18.4
kernel matching	0.004	7.21	2.3	1.8	14.9

Note: *** indicates significance at the 1% level. + indicates that B is greater than 25%.

4.4. Matching Analysis of Outsourcing Participation Effect in Apple Production

The ATT was estimated by the four matching methods to measure the effect of participation in outsourcing on apple production efficiency and income. The empirical results showed that although a variety of matching methods were used, the direction and degree of the influence of outsourcing on apple production efficiency and income were largely consistent. These findings demonstrated that the estimation results are fairly robust. When the estimation results of the PSM and MLR were compared,

the two models were consistent in the sign of the estimated value. Regarding the magnitude of the estimation values, in addition to apple sales income, the PSM estimates of technology efficiency, labor productivity, land productivity, capital productivity, and apple net income were all larger than the MLR estimates. The MLR model was only regressed by controlling the observable covariates and neglected the self-selected issue of participation in outsourcing. However, the PSM model is based on the counterfactual analysis framework, which assumes that the missing variables are only controlled by the observable covariates, so the outsourcing of apple production was separated from other factors affecting the apple production efficiency and income through hierarchical matching of covariates, and thus, the estimation results of the PSM were more accurate and reliable.

We used the PSM model to estimate the treatment effects of outsourcing. The ATT is shown in Table 5. Notably, the ATT is the actual effect of outsourcing participation. Specifically, participation in the outsourcing of apple production had a positive effect on apple farmers' technology efficiency, labor productivity, land productivity, and capital productivity. This finding suggests that, other factors aside, outsourcing participation, on average, significantly increased the apple production of technology efficiency by 5.60 percentage points, labor productivity by 2121.48 kg/person, land productivity by 334.50 kg/mu, and capital productivity by 0.05 kg/Yuan. A possible explanation for this result is that participation in the outsourcing of apple production can compensate for the shortage in domestic laborers caused by transfer and the shortcomings caused by insufficient human capital. Outsourcing also significantly promotes the improvement in apple production technology efficiency [25], labor productivity [41], and land productivity [13]. Theoretical assumptions were verified. However, capital investment is a hard constraint in the process of apple production, i.e., no matter how the output of apples changes, the input of capital elements (such as fertilizer and pesticide) is rigid. Based on the statistical analysis of the survey data, the average capital input of apple farmers accounted for 67.20% of the total apple input. As the input of capital elements increased, the marginal output of capital elements diminished. Thus, the coefficient between outsourcing and capital productivity is positive but not statistically significant. In addition, participation in the outsourcing of apple production had the greatest effect on the promotion of labor productivity. At present, the employment of laborers plays a dominant role in the outsourcing of apple production, and labor-intensive industries (such as the apple industry) have become the main production types absorbing rural labor. This, to a certain extent, highlights the importance of the rural labor market in the agricultural market.

Table 5. Average treatment effect of outsourcing of apple production.

Matching Method	Technology Efficiency	Labor Productivity	Land Productivity	Capital Productivity	Apple Revenue	Apple Profit
K-nearest neighbor matching	0.0576 ***	2123.8743 ***	326.5244 **	0.0495	13,237.1130 ***	−4958.4703 *
Caliper matching	0.0550 ***	2127.6255 ***	349.2802 ***	0.0436	13,460.1154 ***	−4982.5345 *
K-nearest matching in caliper	0.0582 ***	2131.3836 ***	323.3120 **	0.0512	13,315.8987 ***	−4832.1668 *
kernel matching	0.0530 ***	2103.0209 ***	338.8790 ***	0.0381	13,188.4661 ***	−5219.5079 *
Mean	0.0560	2121.4761	334.4989	0.0456	13,300.3983	−4998.1699

Note: K-nearest matching is performed for one-to-four matching. The caliper range is 0.02 for caliper matching. As discussed by Abadie et al. [42], a one-to-four match can generally minimize the mean square error (MSE), and thus, the k-nearest neighbor matching in the caliper is one-to-four matching with a caliper range of 0.02. The core matching uses a default bandwidth of 0.06. The average value is the mean value of the average treatment effect on the treated (ATT) obtained from the above four matching methods.

The results presented in Table 5 show that participation in the outsourcing of apple production has a significant positive effect on farmers' apple sales income but a significant inhibitory effect on apple net income. A possible explanation for this result is that the outsourcing of apple production increased the apple production efficiency through a division of labor, which then increased the apple output and apple sales income. The average apple sales income of the apple farmers who participated in outsourcing increased by 13,300.40 Yuan. However, participation in the outsourcing of apple

production reduced the apple net income by 4998.17 Yuan, on average. This result is a consequence of the labor-intensive feature of the apple industry, and apple farmers are constrained by family agricultural labor resources. Due to the need for employees and the low degree of mechanization, the opportunity for roundabout production through the purchase of machinery from industry is relatively limited. Therefore, apple farmers are inclined to become involved in the outsourcing of apple production through employment during the busiest seasons, which considerably increases labor costs. In addition, the rural outsourcing market is underdeveloped and unregulated, and the relaxed regulation of rural laborer mobility and the seasonal shortage of supply are still prominent at this stage in China. These characteristics suggest that the employment costs of rural labor remain at a high level. The difficulty of supervising employees increases the transaction costs of outsourcing and reduces the farmers' apple net income. Therefore, participation in the outsourcing of apple production has a negative impact on the apple net income of farmers.

In summary, this observation confirms that the outsourcing of apple production is an important factor in explaining the improvement in apple production productivity and the decline in apple net income. Those results also support the findings of the relationship between outsourcing participation, productivity effect, and income effect.

5. Conclusions and Policy Implications

Studies on the effect of farmers' participation in outsourcing are relatively scarce. This study aimed to examine the effect of outsourcing participation on apple production productivity and income based on cross-sectional data from 960 rural households in Shandong, Shaanxi, and Gansu provinces in China. A MLR model was used to estimate the effect of participation in outsourcing without considering the influence of heterogeneity. A PSM model was employed to address the potential selectivity bias from both observed factors. The results showed that outsourcing participation had a positive and significant impact on technology efficiency, labor productivity, land productivity, and apple sales income but a significant negative impact on apple net income. In particular, the ATT estimates showed that outsourcing participation, on average, increases the technology efficiency by 5.60%, labor productivity by 2121.48 kg/person, land productivity by 334.50 kg/mu, capital productivity by 0.05 kg/Yuan, and apple sales income by 13,300.40 Yuan, and decreases the apple net income by 4998.17 Yuan. Although outsourcing participation increased farmers' apple income by increasing apple productivity, the increase in labor input costs and transaction costs reduced the apple net income.

With reference to the factors that affect the farmers' decisions to outsource, the empirical results demonstrated that the decision to outsource is associated with age, education, the number of apple laborers, growing experience, the proportion of income derived from agriculture, and the scale of planting in the household. Overall, our results support the conclusion that outsourcing increases apple sales income by increasing productivity.

The outsourcing of apple production is an important method to achieve the transformation of apple production from a land-scale operation to a service-scale operation. We concluded that outsourcing participation increases agricultural productivity and household income. Thus, to introduce smallholder farmer production into the developmental track of the modern apple industry, relevant policies encouraging more specialized market-oriented services, particularly labor-substituting services, can facilitate the adoption of outsourcing and reduce the cost of participation in outsourcing.

This study only discussed the effect of outsourcing participation on apple production productivity and income by using the MLR and PSM models, thus providing some insights concerning where practice and research may evolve in the future. The mechanism of the impact of production outsourcing on farmers' income must be elucidated for further analysis, and it is necessary to adopt some econometric techniques to address the endogeneity issue that may be caused by the unobserved heterogeneity among farmers in future research.

Conflicts of Interest: The authors declare no conflicts of interest.

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