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Labor Structure, Land Fragmentation, and Land-Use Efficiency from the Perspective of Mediation Effect: Based on a Survey of Garlic Growers in Lanling, China

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Abstract: In the context of China's agricultural labor shortage and the pressure of aging, this paper uses the land fragmentation index and the intermediary efficiency model to measure the degree of land fragmentation based on farmer-level data from the main garlic producing area in Lanling County in Shandong Province in 2020. The direct effect of labor structure on land-use efficiency and the mediating effect through land fragmentation are analyzed. The research results show that: (1) the average land-use efficiency of the sample farmers is relatively low; (2) the change in labor structure has an "inverted U"-shaped direct effect on land-use efficiency; and (3) the change in land fragmentation in the labor structure has a direct effect on land-use efficiency. The influence of land-use efficiency played a nonlinear mediating effect. The change in labor structure with the degree of land fragmentation showed an "inverted U"-shaped relationship, and the degree of land fragmentation and land-use efficiency had a "U"-shaped relationship. In order to improve land-use efficiency, two aspects of policy support should be increased: encouraging farmers to integrate land and supporting specialized and diversified planting.



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Keywords: labor force structure; land fragmentation; land-use efficiency; intermediary effect; Lanling County

1. Introduction

Since the 1980s, the non-agricultural transfer of large rural labor forces in China has prompted changes in the structure of the rural labor force—the aging of the rural labor force has deepened [1]. The establishment of China's market economy system has caused the young labor force in the central and western regions to transfer to coastal areas and developed cities to engage in labor-intensive industries, service industries, and urban construction industries, resulting in a decline in the number of young and middle-aged people in the labor force in rural areas [2–4]. The size of the aging rural population engaged in agricultural production continues to increase, and "aging agriculture" has become one of the typical characteristics of China's agricultural production.

There have been effects of the labor force structure change caused by labor aging on land use efficiency. Judging from the macro level, the essence of labor aging is the incongruity and mismatch between the changes in the labor force age structure and economic and social development [5]. From the micro level, the aging of the labor force and the use of limited land are not necessarily coordinated and matched. As the basic unit of agricultural production and management, peasant households are the direct users of land, so changes in the age structure of the labor force are closely related to land-use efficiency [6], but there are disputes or inconsistencies in the research conclusions on the relationship between the two. Some scholars believe that the aging of the agricultural labor force has a significant impact on the labor input in agricultural production; however, agricultural production is a repetitive activity, and the impact of technical know-how is small, so age has no significant

effect on the utilization efficiency of cultivated land [7]. However, there are also studies showing that the age of farmers and the proportion of family labor have a negative impact on land-use efficiency [8,9]. The age and health of workers are influencing factors, and similarly, the scale of land cultivation also affects the efficiency of land use [10]. The land-use efficiency of the old farmers presents an inverted “U”-shaped relationship. The land-use efficiency of the farmers is only 71.63%, and the efficiency loss is significant [11]. Labor and land input significantly affect the total agricultural output [10]. Appropriate employment of labor and the intensive planting of land can improve agricultural economic benefits [12], while the insufficient labor supply and land loss caused by idle land have a serious negative impact on agricultural economic benefits [13].

Land fragmentation refers to the fact that, within a certain geographical space, the land operated by farmers is scattered and not contiguous or a certain area of land is cultivated by multiple farmers [14]. The problem of land fragmentation is particularly serious in China. There are both historical reasons for the equal distribution of land under the household contract system as well as a combination of good, bad, and practical reasons, including the shortage of per-capita land resources [14–16]. The research results on agricultural production efficiency all report that land fragmentation has a significant negative impact on production efficiency and reduces agricultural output [17–21]. Land fragmentation is not only a major problem in Chinese agriculture but other studies in Nepal [22], Bangladesh [19], and Nigeria [23] have also concluded that land fragmentation has a significant negative effect on agricultural production efficiency. Of course, some researchers believe that the relationship between land fragmentation and agricultural production efficiency is not clear. For example, Bentley’s research on villages in northwestern Portugal pointed out that land fragmentation neither reduces nor improves agricultural production efficiency; that is, land fragmentation is not an inevitable cause of low agricultural production efficiency [24]. Niroula et al. analyzed rice production in Malaysia and the Philippines and found that land fragmentation had no significant impact on rice production efficiency [25].

A review of existing studies found that land fragmentation mainly affects agricultural production by affecting the input of production factors. In terms of labor input, land fragmentation increases labor input, reduces labor efficiency and labor marginal efficiency, and causes labor competition. The increase in labor input has obvious crowding-out effects on other production factors [26,27].

To sum up, the academic community is highly concerned about the aging of the agricultural labor force and its impact on land-use efficiency, but the research ideas and methods are quite different, and research conclusions are also inconsistent. When scholars studied land fragmentation in the past, they seldom studied the land fragmentation problem of labor-intensive crops such as garlic and mostly took rice and corn as the main field crops for the subject of their research. There is a lack of research on land-use efficiency in China. By analyzing the impression of garlic growers’ land efficiency, suggestions for improving garlic planting productivity can be put forward. Therefore, the research results of this paper are a useful supplement to the theory of land-use efficiency.

Lanling County in Shandong Province is one of the two main garlic producing areas in China, with stores of 40,000 tons of garlic, accounting for 59.56% of the world’s garlic harvest area and output. In the first quarter of 2019 alone, China’s garlic export volume was 633,000 tons, with an output value of USD 780 million. As garlic is a labor-intensive agricultural product with high added value, the garlic industry has played an important role in absorbing agricultural labor and increasing foreign exchange earnings and the rural population’s income.

Under the realistic background that the aging of the labor force in Lanling County has existed for a long time and become increasingly serious, it is of great significance to clarify the changes in labor force structure and the impact of land fragmentation on land-use efficiency to promote the development of modern agriculture for garlic cultivation in Lanling County. Judging from the existing literature, the academic community has conducted a lot of beneficial explorations of the impact of labor aging and land fragmentation on land-use

efficiency, which has laid an important foundation for this research. However, it is worth further supplementing and improving in the following aspects. Firstly, the nonlinear effect of labor aging on the land-use efficiency of labor-intensive cash crops may be an important reason for the inconsistent conclusions of existing studies, but there are few relevant studies; secondly, in addition to the direct impact, the aging of the labor force promotes the change in labor force structure, which has an indirect impact on land-use efficiency by affecting farmers' planting decisions. Nevertheless, no scholars have paid attention to the mediating role of farmers' land fragmentation behavior. Finally, from a nonlinear perspective, this paper theoretically analyzes the direct effect of changes in labor structure on land-use efficiency and the indirect effect through land fragmentation transmission and uses the main garlic production area in Lanling County in Shandong Province as an observation point, using the Tobit regression model and mediation effect model to conduct empirical tests. This paper uses age to measure the change in labor structure, calculates the change in labor structure with the rate of family aging, calculates the land fragmentation index as the standard to measure the degree of land fragmentation, uses the unit land output value as the land-use efficiency, and studies the relationship between labor structure, land fragmentation, and land-use efficiency.

2. Analytical Framework and Research Hypotheses

2.1. *The Direct Influence of Labor Structure Change and Land-Use Efficiency*

The dominant factor in production for garlic planting is labor, which is a powerful guarantee for improving labor productivity and economic benefits. In agricultural production, especially in the production of labor-intensive cash crops, land-use efficiency is closely related to the labor force structure. The existing literature usually divides the labor force structure according to six dimensions: age, gender, education level, sector, occupation, and economic form. Since this paper studies garlic growers in the context of an aging labor force, we chose the aging rate of the family to measure the changes in their labor force structure. In terms of age structure, the aging of the agricultural labor force is caused by the transfer of the rural young and middle-aged labor forces to the urban non-agricultural sector, and the existing research shows obvious differences in the impact of labor aging in the field of agricultural production.

Peng Daiyan et al. used the panel data of 27 provinces and regions from 2003 to 2007 and concluded that the aging of the agricultural labor force improves the technical efficiency of grain production [28]. Based on the analysis of fixed observation point data in rural areas from 2003 to 2010, Hu Xuezhi et al. found that the aging of the agricultural population has no negative impact on China's food production [29]. On the contrary, Guo Xiaoming et al. concluded through a micro survey of 501 farmers in three representative agricultural areas in Sichuan Province that the aging of the agricultural labor force is an important obstacle to progress in agricultural technology, which may lead to the regression of agricultural modernization [30]. Using the data of fixed observation points in rural areas from 2003 to 2010, Hu Xuezhi et al. concluded that aging has a negative impact on cotton crops with a high degree of collective decision-making but low degree of mechanization [31]. Chen Xiwen et al., through the empirical study of the rural fixed observation data of Liaoning Province from 2003 to 2006 [32], and Li Min et al. also found that aging of agricultural labor force is detrimental to agricultural production [33]. Analyzing the demographic and labor force data from the United States, Thiede concluded that most of the rural areas and communities in the United States have a high degree of aging, which affects social production [34]. The results of research by Bashir et al. show that in potato production, the age of the grower has a negative effect on the efficiency of production technology [35]. With the increase in the number of elderly family members, the restriction of the household labor endowment reduces land-use efficiency.

In conclusion, changes in the labor structure promote land-use efficiency to a certain extent, but with labor endowment constraints, land-use efficiency decreases. Therefore, this paper assumes the following hypotheses.

Hypothesis 1. *There is an “inverted U” relationship between labor structure change (LS) and land-use efficiency (LE).*

2.2. The Mediating Effect of Land Fragmentation (SI) on Labor Structure (LS) Affects Land-Use Efficiency

Generally speaking, the goals of farmers’ planting decisions include the pursuit of profit, risk control, and labor-saving [36]. This paper discusses the impact of changes in the labor structure of garlic growers on land fragmentation from three aspects: labor-saving, the pursuit of profit, and risk control.

Firstly, changes in workforce structure increase labor input, while land fragmentation aggravates the labor endowment constraint effect, making it difficult to achieve the decision-making goal of saving labor. Because cash crops have a more prominent labor-intensive attribute, this means that more labor input is needed [37], although changing the labor structure, increasing youth labor input, and reducing the rate of family aging can yield higher returns. However, with the increase in the number of operating plots, the labor endowment constraint effect still exists, and the impact of labor structure changes on land-use efficiency is gradually increasing. Under the enlargement of land fragmentation, the cultivation of cash crops is bound to have a stronger demand for labor. However, the continuous increase in agricultural labor costs, the continuous changes in the labor force structure, and the continuous increase in the aging family labor force have all adversely affected farmers’ land-use efficiency. Secondly, under the constraints of changes in the labor force structure, farmers pursue profits through land fragmentation as rational human behaviors. With the reduction of agricultural labor, the shortage of agricultural labor may lead to the outward transfer of rural land [38]. Specialized production inevitably leads to a mismatch between planting systems and land resource endowments, making it difficult to achieve the decision-making goal of maximizing profits [39]. There is a complementary relationship between land and other production factors, and the fragmentation of plots increases the difficulty of field management and deepens endogenous risks, such as delayed farming and poor management [40]. Therefore, farmers choose to transfer land to balance their household income [41].

Finally, some scholars believe that farmland fragmentation is not necessarily a problem. The scenarios and extent to which it becomes problematic or beneficial depend on a combination of many locally specific external environments, ranging from biophysical, social, economic, political, and technological to agro-ecological [42]. With the slow growth of agricultural income and imperfect social insurance in rural areas, farmers often pursue risk aversion. The degree of land fragmentation increases the operation risk for farmers and reduces the marginal productivity of agricultural labor.

To sum up, changes in the labor force structure affect land-use efficiency through the change in the degree of land fragmentation. The further aggravation of labor endowment constraints leads to the deepening of land fragmentation, and the increase in the aging labor force leads to the integration of land circulation, thus affecting the efficiency of land use. Accordingly, this paper proposes the corresponding hypothesis:

Hypothesis 2. *There is an “inverted U” relationship between the change in labor structure (LS) and land fragmentation (SI).*

2.3. The Direct Effect of Land Fragmentation on Land-Use Efficiency

Land use efficiency in garlic farming mainly depends on agricultural production technology, input level and natural conditions. Among them, agricultural production technology is usually reflected in the direct input of agriculture, and the natural conditions are uncontrollable. Therefore, in general, land-use efficiency is determined by direct inputs such as labor input, chemical fertilizers, pesticides and agricultural film inputs, and agricultural machinery inputs.

With the development of the rural economy and the continuous transfer of agricultural labor to the non-agricultural sector, especially the result of the era of unlimited

supply of labor beam [43]. As labor costs continue to rise, it has become a trend to re-place labor by machinery. Smaller plots that require more labor input and are not conducive to mechanical operations are likely to be abandoned due to high production costs. In this scenario, land fragmentation reduces land production efficiency and labor productivity, which is ultimately detrimental to agricultural production [44–48]. Land subdivision increases the operational cost of labor input, agricultural input and labor employment. Due to the scattered plots, farmers waste a lot of time moving back and forth between plots, which increases the cost of field management; the loss of production materials during transportation between plots increases, making farmers additionally increase the number of production factors; hindering agricultural machinery Effective substitution of labor restricts the adoption and application of technology, thereby increasing its own labor input and labor costs [17,49–52]. At the same time, land fragmentation will restrict the spatial spillover effect of agricultural infrastructure in-vestment. Farmers are more willing to increase investment in concentrated and contiguous plots [53], while scattered small plots are more likely to be extensively managed, and even the phenomenon of abandoning farmland [54]. The efficient use of scarce and fragmented land poses a threat to the sustainability of agriculture [55]. On the other hand, farmers have limited willingness to build roads and irrigation and drainage on their own plots, and farmers need high negotiation costs, which inhibits spontaneous investment behavior. Small-scale scattered plots lead to unreasonable allocation of agricultural production factors, increase the technical inefficiency, and reduce agricultural profits and efficiency [45]. Wan and Cheng found that the technical efficiency of maize decreased by 4% for each unit of increase in the degree of fineness, and 15% and 17% for late rice and wheat, respectively [56]. Using the survey data of 1987 and 1988 to estimate food production, Fleisher et al. found that if the number of plots in the sample area was reduced from 4 to 1, the total factor productivity would increase by 8% [57]. The exchange of farmland by farmers can effectively solve the phenomenon that farmers' plots are too small and scattered, thereby improving agricultural production efficiency.

Accordingly, this paper proposes a hypothesis:

Hypothesis 3. *There is a “U”-shaped relationship between land fragmentation (SI) and land-use efficiency (LE).*

This paper summarizes the mechanism of labor structure and land fragmentation on land-use efficiency (Figure 1).

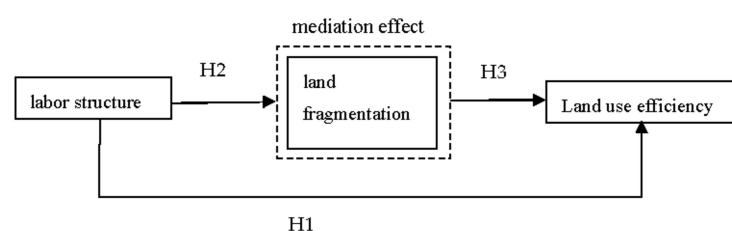


Figure 1. Analysis framework for the impact of labor structure and land fragmentation on land-use efficiency.

The dispersion of land has caused low land-use efficiency. Although land transfer has improved land-use efficiency, many households are reluctant to give up land to improve efficiency, and labor market failure has led to a large increase in agricultural labor, which has prompted land transfer to have a positive impact [55]. Part of the reason for the increase in labor input is the rent generated by land transfer and the motivation of farmers to pursue profits. Although with the increase in land rent and profits from land transfer, the lessee family has more labor to engage in agriculture, which can alleviate the shortage of agricultural labor. [58]. However, it did not change the county-level agricultural land-use efficiency being lower than the national average efficiency level [59]. From the above, it can be seen that changes in the labor force structure have a certain impact on land fragmentation.

The impact of land fragmentation affects the application of agricultural machinery, thereby hindering the efficiency of land use [60,61]. However, land can be used efficiently through diversified planting, and the potential negative impact of diversified planting on labor and other resource use efficiency is affected by its higher land-use efficiency. Therefore, the effect of land fragmentation on land-use efficiency presents a nonlinear effect [62].

3. Data, Methods and Variables

3.1. Data Sources

The empirical analysis data in this paper comes from the primary data collected by the author in 2020 by visiting and investigating 84 villages under the jurisdiction of Changcheng Town, Lanling Town, Moshan Town, and Shenshan Town in Lanling County, Linyi City, Shandong Province. The survey method adopts a random sampling questionnaire survey and interview survey of visiting farmers. A total of 709 questionnaires were distributed, 15 invalid questionnaires were excluded, and a total of 694 valid questionnaires were collected, with an effective rate of 97.88%. The questionnaire has five main parts, including the basic family information of the garlic growers, the planting area and yield of the garlic growers, various inputs of the garlic growers, the annual income of the garlic growers, and other information, and the investigation of the influencing factors in the production of the garlic growers. It effectively covers the relevant information to be analyzed in the paper. The sampling method adopts a combination of stratified sampling and random sampling, and the survey form is a household interview and questionnaire survey. The corresponding time for all data and indicators is 2020, which has a strong academic research representation. The definition and descriptive statistics of each variable are shown in Table 1.

Table 1. Variable settings and descriptive statistics.

The Variable Type	Variable	Symbol	Variable Definitions	Mean	Standard Deviation
Dependent variable	Land-use efficiency	LE	Output per unit of land after deducting material input and labor input costs (standardized)	0.36	0.148
Independent variable	Labor structure	LS	Family aging rate	0.325	0.315
Mediating variable	Land fragmentation	SI	Fragmentation index	0.422	0.138
Control variable	Age	AGE	Age	56.993	12.8
	Years of education	EDU	Year	1.8	0.872
	Health	HEA	0 = incapacitated; 1 = poor; 2 = moderate; 3 = good; 4 = excellent	2.04	0.735
	Technical training	TEC	0 = not participating; 1 = participating people	0.7	0.458
	Number of labor	LAB	Number	2.516	0.991
	Per capita household income	INC	Household income level in the previous year (ten thousand yuan)	1.508	1.349
	Village cadre	VC	0 = no; 1 = yes	0.016	0.125
	Scale	SCA	Mu	5.5	2.725

Note: 1. The data were obtained by the members of the research team on the field survey in Lanling County, Shandong; 2. For the convenience of analysis, some variables have been classified and adjusted to the original data.

3.2. Research Methods

The mediation effect model. According to the previous analysis, the change in the age structure of farmers not only directly affects land-use efficiency but also indirectly affects land-use efficiency through the transmission mechanism of the degree of land fragmentation. Referring to the mediation effect analysis framework proposed by Wen

Zhonglin et al. [63], combined with the research hypothesis of this paper, the following hierarchical regression model was constructed:

$$LE_i = a_0 + a_1LS_i + a_2LS_i^2 + a_3Z_i + \mu_{1i} + \gamma_{1i} + e_{1i} \quad (1)$$

$$SI_i = b_0 + b_1LS_i + b_2LS_i^2 + b_3Z_i + \mu_{2i} + \gamma_{2i} + e_{2i} \quad (2)$$

$$LE_i = c_0 + c_1LS + c_2LS_i^2 + c_3SI_i + c_4SI_i^2 + \mu_{3i} + \gamma_{3i} + e_{3i} \quad (3)$$

In the above model, i represents the farmer, LE represents the land-use efficiency of the dependent variable, SI represents the level of land fragmentation as an independent variable, LS represents the labor force structure of the mediator variable, and Z represents the control variable; μ_i represents the fixed effect of the individual, and e_i represents the random disturbance term. Equation (1) is a total effect model, which is used to investigate the overall impact of labor structure on land-use efficiency. A square term is introduced into the model to capture the nonlinear effect of labor structure on land-use efficiency; Equation (2) is used to estimate the impact of labor structure on land fragmentation; Equation (3) simultaneously introduces land fragmentation, labor force structure changes, and their square terms, which are used to estimate the direct effect of land fragmentation on land-use efficiency and take the mediation effects of land fragmentation on the impact of labor structure change on land-use efficiency. When a_1 , a_2 , b_1 , b_2 , c_1 , c_2 , c_3 , and c_4 are all significant, it is considered that labor structure not only has a direct nonlinear effect on land-use efficiency but also has an indirect effect on land-use efficiency through the conduction mechanism of land fragmentation. Considering the traditional mediation effect test, the three-step regression method may have difficulty in accurately revealing the nonlinear interaction path between variables [64]. In order to ensure the reliability of the research conclusions, this paper refers to the analysis framework proposed by Edwards et al. [38] and introduces the mediator variable and its square terms SI and SI^2 into the total effect measurement Equation (4) as well as the interaction variables $LS \times SI$ and $LS^2 \times SI$, which reflect the nonlinear effect path of the independent variable on the mediator variable. A new Equation (4) is formed to further test the robustness of the interaction mechanism between variables. By comparing the regression coefficients of the independent variable and the mediator variable in Formula (4) and Formula (1), it can be judged whether the mediation effect is significant. Specifically, the following conditions must be met: first, d_1 , d_2 are significant and the direction is consistent with a_1 , a_2 in Formula (1), and a_2 remains the same; secondly, d_3 , d_4 need to pass the test; finally, d_5 , d_6 also pass the test.

$$LE_i = d_0 + d_1LS + d_2LS_i^2 + d_3SI_i + d_4SI_i^2 + d_5LS \cdot SI + d_6LS^2 \cdot SI + d_7Z_i + \mu_{4i} + \gamma_{4i} + e_{4i} \quad (4)$$

3.3. Variable Selection

- a. Dependent variable: land-use efficiency (LE). This paper follows the concept of agricultural productivity by Shi Qinghua [65]; that is, land-use efficiency is the output value per unit of land. Since the output value is mostly a value greater than 1, the output value is standardized and set at $[0, 1]$, while the output value is closely related to the price. Therefore, this paper excludes the impact of changes in the price of agricultural products in practical applications. In this paper, the indicator for measuring land-use efficiency is the output per unit of land after deducting the cost of material input and labor input. In view of the research purpose of this paper, this paper focuses on the output per unit without deducting the input cost. The reason for this is that the land-use efficiency multiplied by the actual land area constitutes the total output of garlic cultivation, which can reflect the security level of agricultural production.
- b. Independent variable: labor force structure (LS). This paper measures the changes in labor force structure by age, and calculates labor force structure changes in the family aging rate.

- c. Mediating variable: land fragmentation (SI). The degree of fragmentation reflects the impact of the number of plots on land use and is measured by the fragmentation index SI:

$$SI = 1 - \frac{\sum_{i=1}^n \alpha_i^2}{(\sum_{i=1}^n \alpha_i)^2} \quad (5)$$

In the formula, n refers to the number of plots, which refers to the land area of the i -th plot; the SI value is between 0, and the larger the value, the more plots and the higher degree of fragmentation, which is not conducive to mechanical operation and increases the waste of land boundaries.

- d. Control variables. In order to avoid the bias of model estimation results caused by omission variables, according to the existing research, this paper controls variables from three dimensions: household characteristics, family characteristics, and land characteristics. It includes the age of the head of the household, the years of education of the head of the household, the health of the head of the household, whether agricultural technical training is conducted, the number of family members participating in labor, the per capita income level of the family, whether it is a village cadre family, and the scale of land management. The variable settings and descriptive statistics are shown in Table 1.

4. Empirical Results and Discussion

4.1. Estimation of Land-Use Efficiency Based on the Tobit Regression Model

4.1.1. Estimation of the Results

According to the previous Tobit regression estimation of the dependent variable land-use efficiency using Stata16.0 software (Statacorp, 1985, Chicago, IL, USA) (Table 2), from the coefficient direction of the input variable, the primary term of land area has passed the 1% significance level test and the coefficient is positive, which means land area can effectively promote the increase in output. The quadratic items of farmers' age and land area passed the 1% significance test, and the coefficients of the quadratic items were all negative. It can be seen that the influence of farmers' age and land on agricultural output presents an "inverted U"-shaped relationship. In addition, the interaction item of capital investment and farmers' age, the interaction item of capital investment and land area, and the interaction item of farmers' age and land area all passed the test under the significance of 1%, among which farmers' age and land area were significantly negatively correlated.

Table 2. Tobit model estimation results.

Variable	Coefficient	Standard Error	Variable	Coefficient	Standard Error
Age	−0.0023935	0.007466	Age * land	−0.0044595 ***	0.0003919
Land	0.3230521 ***	0.031638	Land * input	0.0279382 ***	0.001318
Input	−0.0852631	0.4126069	Age * input	0.0136334 ***	0.000178
(Age) ²	−0.0002538 ***	0.0000614	Log likelihood	−87.302505	
(Land) ²	−0.0174603 ***	0.0017427	LR chi2(9)	0.0000 ***	
(Input) ²	0.2124786	0.4997218	Observations	694	

Note: 1. The T value is in parentheses in the table; 2. *, ** indicate that the statistical value is significant at the statistical level of 10%, 5%, and 1%, respectively; 3. The data were obtained by the members of the research team conducting field investigations in Lanling County, Shandong.

4.1.2. Statistical Analysis

According to the distribution of land-use efficiency (Table 3), it can be seen that the farmers in the low-efficiency range ($LE \leq 0.2$) are the most, accounting for 63.54%; the average land-use efficiency of the sampled farmers is 0.18.

Table 3. The distribution of land-use efficiency.

Index	$LE \leq 0.2$	$0.2 < LE \leq 0.4$	$0.4 < LE \leq 0.6$	$0.6 < LE \leq 0.8$	$0.8 < LE \leq 1.0$
Samples	441	232	17	2	1
Proportion (%)	63.54	33.42	2.45	0.29	0.14

Note: 1. The data were obtained by the members of the research team on the field survey in Lanling County, Shandong. 2. For the convenience of analysis, some variables have been classified and adjusted to the original data.

In this paper, the SI value, which is the characterization index of land fragmentation, was used to make cross-statistics on the land-use efficiency and the labor aging rate so as to preliminarily judge the relationship between the variables. The results are shown in Table 4. According to the statistical results, it can be found that, first of all, the degree of land fragmentation of the sampled farmers is very serious, and the SI index of 82.7% of the sampled farmers is above 0.6, and the proportion of the households with the SI index above 0.8 is 15.7. Secondly, as the degree of land fragmentation increases, the aging rate of the labor force showed an “inverted U-shaped” trend of a nonlinear relationship that first increased and then decreased. Finally, with the change in the degree of land fragmentation, the land-use efficiency showed a “U-shaped” trend of first decreasing and then increasing.

Table 4. Cross-statistical analysis of SI, LE and LS.

Index	$SI \leq 0.2$	$0.2 < SI \leq 0.4$	$0.4 < SI \leq 0.6$	$0.6 < SI \leq 0.8$	$0.8 < SI \leq 1.0$
Samples	12	13	95	465	109
Proportion (%)	0.14	1.87	13.69	67	15.7
Mean (LS)	0.4	0.54	0.37	0.32	0.26
Mean (LE)	0.12	0.1	0.16	0.18	0.22

Note: 1. The data were obtained by the members of the research team on the field survey in Lanling County, Shandong. 2. For the convenience of analysis, some variables have been classified and adjusted to the original data.

Further, a cross-analysis of land-use efficiency was conducted using the labor force aging rate, and the results are shown in Table 5. It can be seen that the vast majority of peasant households have a large number of aging laborers. As the aging rate of the labor force increases, the land-use efficiency shows an “inverted U-shaped” trend of rising first and then falling.

Table 5. Cross statistical analysis of LE and LS.

Index	$LS \leq 0.2$	$0.2 < LS \leq 0.6$	$0.6 < LS \leq 1$
Samples	277	309	108
Proportion (%)	39.9	44.5	15.6
Mean (LE)	0.18	0.19	0.15

Note: 1. The data were obtained by the members of the research team on the field survey in Lanling County, Shandong. 2. For the convenience of analysis, some variables have been classified and adjusted to the original data.

In summary, in garlic production and planting, the relationship between land fragmentation, labor structure changes, and land-use efficiency is not a simple linear relationship, and the effects of land fragmentation on labor structure change, land fragmentation on land-use efficiency, and labor structure change on land-use efficiency are nonlinear. The research hypothesis of this paper has been preliminary verified, but the mechanism of action between variables needs to be further empirically tested.

4.2. Mechanism Test Based on the Mediation Effect Model

4.2.1. Hierarchical Regression Analysis

According to the test Equations (1)–(3) of the mediation effect constructed above, further empirical analysis was performed on the influence mechanism of labor structure change and land fragmentation on land-use efficiency. The explained variable of

Equations (1) and (3) is land-use efficiency, and the explained variable of Equation (2) is the land fragmentation index, with values ranging from 0 to 1, which is in line with the characteristics of restricted dependent variables; the Tobit model is still used for regression.

According to the estimation results of model (2), it can be seen that the coefficient of the first-order term of the labor structure variable is positive and passes the test at the 5% significance level. The quadratic coefficient of the labor force structure variable is negative, passing the test at the significance level of 1% and shows that the total effect of labor structure on land technical efficiency shows a significant “inverted U” relationship. The change in labor structure causes the increase in land-use efficiency. After reaching the inflection point, the labor force structure change caused by continued increase in aging leads to a loss of land-use efficiency. As for the control variable, the coefficient of the farmers’ age variable is positive, and it passes the test at the 5% significance level, indicating that the increase in the farmers’ age can promote the land-use efficiency to a certain extent. The variable of farmers’ health condition passed the test at the 5% significance level. Under other conditions being equal, the higher health degree of farmers improves the land-use efficiency, and the more abundant labor factors promote the improvement of land-use efficiency. At the same time, the planting scale variable passed the test at the 1% significance level, and the planting scale was positively correlated with land-use efficiency. A certain scale of planting promotes the improvement of land-use efficiency, and the appropriate increase in the planting scale allows farmers to adopt appropriate additions to mechanized production, thereby reducing labor endowment constraints. However, due to the labor-intensive property of cash crops, when the scale of farmland exceeds the rigid constraints of labor, it induces extensive management and reduces land-use efficiency.

In model (4), the first-order coefficient of the labor structure variable is positive and passes the test at the 1% significance level. The quadratic coefficient of the labor structure variable is negative and passes the test at the 1% significance level. The test shows that there is an “inverted U”, nonlinear relationship between labor structure and land fragmentation, and the hypothesis H3 of this paper is verified. When the labor force structure variable is lower than the critical value, it promotes land fragmentation to a certain extent, and the increase in the aging labor force promotes land transfer due to limited physical energy, which leads to further intensification of land fragmentation; however, when the labor force structure variable is higher than the critical value, it hinders land fragmentation and achieves land integration to a certain extent. For the control variable, the coefficient of education level of the head of household is positive, which passes the test at the significance level of 10%, and the coefficient of whether the head of the household has received technical training is positive and passes the test at the 5% significance level. Education represents the general human capital of farmers, while agricultural technical training reflects the specific human capital of peasant households. The above results show that general human capital promotes the degree of land fragmentation, and labor flows to other areas with the improvement of education. The non-agricultural sector, or part-time agricultural planting, promotes the improvement of the degree of land fragmentation. At the same time, specialized human capital also promotes the increase in the degree of land fragmentation. The trained farmers adopt intensive cultivation and refined planting management, which is constrained by labor force endowment, so that part of the land is transferred to improve the degree of land fragmentation.

In model (5), the quadratic coefficient of the labor structure variable is negative, and it passes the test at the 5% significance level, indicating that the labor structure change has an “inverted U”-shaped direct effect on land production efficiency, which verifies the hypothesis H2. When the aging rate of the household labor force is low, farmers hinder the efficiency of land use because of factors such as less capital investment and less planting experience; when the aging family labor force exceeds the critical point, the labor force loss hinders technological progress due to the physical constraints of the farmer’s own age, which directly leads to the loss of land-use efficiency. The coefficient of the first-order term of land fragmentation is negative, and the test is passed at the 5% level of significance.

The coefficient of the quadratic term is positive, and the test is passed at the 1% level of significance. Combined with model (4), it can be seen that the change in labor structure not only directly affects land-use efficiency, but also indirectly affects land fragmentation, which also means that land fragmentation has a nonlinear intermediary effect on land-use efficiency. H1 of this paper has been verified. Land fragmentation inhibits the specialization effect. When the degree of land fragmentation exceeds the critical value, it is difficult to improve land-use efficiency by means of specialized production and it is also difficult to achieve scope economy through scale operation, which leads to the loss of land-use efficiency. When the degree of land fragmentation is lower than the critical value, the scale economy effect makes up for the lack of specialization effect and promotes the improvement of land-use efficiency. Among the control variables, the age of the head of the household passes the test at the 5% significant level, which means that land-use efficiency is highly affected by the age of the laborers; the household labor force is significantly positive, which indicates that the rural labor force continues to transfer at this stage, which has the effect of improving land-use efficiency. The scale is significantly positive, which means that scale operation promotes the improvement of land-use efficiency to a certain extent (Table 6).

Table 6. Hierarchical regression results.

Variable	Dependent Variable LE		Mediating Variable SI		Dependent Variable LE
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
LS		0.0567243 ** 0.034774		0.129325 *** 0.042222	0.056886 0.034933
LS2		−0.0656494 *** 0.035924		−0.1312309 *** 0.043615	−0.0657571 ** 0.036077
SI					−0.1928078 ** 0.094767
SI2					0.1855854 *** 0.095912
AGE	0.0010678 ** 0.00051	0.0010441 ** 0.000513	−0.0001622 0.000622	−0.0002889 0.000622	0.0010887 ** 0.000512
EDU	−0.000664 0.004051	−0.0013714 0.004064	0.010898 0.004942	0.009295 * 0.004935	−0.0017655 0.004063
HEA	0.0154698 ** 0.007612	0.013738 ** 0.007723	−0.0030003 ** 0.00928	−0.0076787 0.009373	0.0147659 * 0.007717
TEC	−0.0064776 0.010375	−0.0051165 0.010749	0.020639 0.012655	0.0268666 ** 0.013053	−0.0063165 0.010755
LAB	0.0079566 ** 0.003867	0.006426 0.004065	−0.0019666 0.004717	−0.0036311 0.004936	0.0068742 * 0.004059
INC	−0.0068307 ** 0.003072	−0.0045638 0.003327	−0.0043428 0.003746	−0.0005382 0.00404	−0.0041571 0.003324
VC	0.015632 0.027596	0.019405 0.027892	0.027149 0.033658	0.03953 0.033865	0.021701 0.027883
SCA	0.0164946 *** 0.001502	0.0161318 *** 0.00154	0.0313579 *** 0.001832	0.0310507 *** 0.001871	0.0172664 *** 0.002033
Chi2	134.65 ***	138.03 ***	347.02 ***	356.50 ***	142.16 ***
Observations	694	694	694	694	694

Note: 1. The T value is in parentheses in the table; 2. *, **, *** indicate that the statistical value is significant at the statistical level of 10%, 5%, and 1%, respectively; 3. The data were obtained by the members of the research team conducting field investigations in Lanling County, Shandong.

4.2.2. Robustness Test

Equation (4) is regressed using the Tobit model, and Table 7 reports the results of the robustness test. It can be seen that the independent variables, mediating variables, and their primary, secondary, and interaction terms pass the test at the 1% or 5% significance level, and the coefficient direction is also consistent with expectations, indicating that the empirical results are robust.

Table 7. Robustness test.

Variable	Dependent Variable LE	
	Coefficient	Standard Error
LS	−0.1156664 ***	0.0630149
LS2	−0.0650116 **	0.0330866
SI	−0.06866 **	0.0954666
SI2	0.2360012 ***	0.0876321
LS * SI	0.2349509 ***	0.0747595
LS2 * SI	0.7305947 **	0.4416784
Control Variable	Controlled	
Chi2	71.43 ***	
Observations	694	

Note: 1. The T value is in parentheses in the table; 2. *, **, *** indicate that the statistical value is significant at the statistical level of 10%, 5%, and 1%, respectively; 3. The data were obtained by the members of the research team conducting field investigations in Lanling County, Shandong.

4.3. Discussion

According to Table 2, it can be concluded that the age of the labor force has an “inverted U”-shaped relationship with the land-use efficiency of garlic. As the age of the farmer grows, the land-use efficiency increases and then decreases after reaching a peak. In this paper, the indicator for measuring land-use efficiency is the output per unit of land after deducting the cost of material input and labor input. Therefore, as the farmers grow older, the planting capacity decreases significantly with the decline of physical energy and energy, thus affecting the farmers’ planting income, while other inputs do not. In the case of change, the reduction of planting income leads to the reduction of land-use efficiency. Farmers’ planting land area and land-use efficiency show an “inverted U” relationship. Small-scale farmers restrict the use of advanced technology and agricultural machinery, so there are higher physical requirements for these farmers, although farmers with large planting scales can use agricultural technology. However, garlic is a labor-intensive crop which is grown by hand, and large scale growers need to hire more workers during harvest time to harvest in the same amount of time as other growers. The employment cost increases due to the increase in the planting scale, which eventually leads to a decrease in planting income and a decrease in land-use efficiency.

According to Table 3, it can be seen that the proportion of farmers with low land-use efficiency is as high as 64.54%; that is, the income of farmers planting garlic is not high. Table 4 further verifies the relationship between changes in labor structure, land fragmentation, and land-use efficiency. The increase in land transfer indicates an increase in the aging of the labor force. The aging labor force transfers land leaving only the land that can be planted within the capacity, which is one of the causes of land fragmentation. With the trend of high and low, young laborers may be more inclined to plant side by side, so the land area for garlic cultivation may be smaller than that of the elderly who grow garlic full-time, which is also one of the reasons for serious land fragmentation. Land fragmentation causes land-use efficiency to show a trend of first decreasing and then increasing. Due to the increased degree of land fragmentation, farmers need to consume a part of the input required for planting between the round-trip land, and the farmers’ time and energy are also consumed in the round-trip. As the number of operating plots increases, the attributes of garlic as a labor-intensive crop are more pronounced, and the labor endowment constraint effect increases, resulting in a decrease in land-use efficiency.

However, as the number of plots increases, farmers are economically rational people, so they use diversified planting; that is, planting different crops in different periods or planting different varieties of the same crop at different harvest times in different periods so they can therefore obtain more income than planting a single variety, and land-use efficiency thereby increases instead.

According to Table 6, the hypothesis is established. The impact of labor structure changes on land-use efficiency is to increase first and then decrease. The increase in the number of middle-aged and elderly laborers in the family promotes the increase in land-use efficiency in a short period of time. The planting experience makes the elderly farmers have a high survival rate for garlic planting. For young farmers, elderly farmers can judge the production materials, such as fertilizers, needed for planting based on the natural environment more accurately than young farmers, so they can obtain higher planting income than young farmers and improve land-use efficiency. However, with the growth of time, as the dominant production factor in garlic planting, labor is the basis for improving labor productivity and economic benefits. The advantages of the elderly labor force, in terms of experience, are gradually overshadowed by physical aging and the disadvantages of health factors. Therefore, land utilization efficiency gradually decreases, thus confirming Hypothesis 1. There are obvious differences in factor inputs for farmers of different ages. The crop sowing area of the elderly farmers is small, but the labor input has a smaller decline than that of the young and middle-aged labor forces. They tend to prolong the labor time and increase the labor input to replace the capital investment. In agricultural production, the agricultural capital input of the young and middle-aged farmers is all the young households have, i.e., the most physical strength but the smallest production scale and the smallest labor input and capital investment, and they are more willing to go out to work to obtain non-agricultural income. Therefore, the increase in the elderly labor force makes it difficult for the labor structure change to achieve the decision-making goal of saving labor and convenience. As an economic crop, the cultivation of garlic is bound to have a high demand for labor, and the employment costs generated by replacing the elderly labor force increase, prompting the elderly labor force, under the constraints of labor resource endowment, to transfer land in order to balance health and family income. Hypothesis 2 is thus established. Finally, the dispersion of land limits the farmer's field management, delays farming time, reduces agricultural production material input, and limits agricultural machinery and equipment, thereby reducing the efficiency of land use. As economically rational men, farmers choose to diversify planting to ensure that, under the constraints of the labor force and other factors, the income required by the family is still guaranteed. Therefore, a certain degree of land fragmentation promotes the efficiency of land use, thereby verifying Hypothesis 3.

5. Conclusions and Implications

The main conclusions of this paper are: (1) The overall land-use efficiency of the sampled farmers is relatively low. (2) Changes in the labor force structure have an “inverted U”-shaped direct effect on land-use efficiency. A mild aging of the labor force is beneficial for farmers to compensate for the shortcomings of increased time costs through additional labor experience and other specialized technologies. With the continuous increase in aging, the effective labor input and capital input tend to decrease, which has a significant negative impact on land-use efficiency. (3) There is a “U”-shaped relationship between land fragmentation and land-use efficiency. Land fragmentation promotes the return of young labor and makes up for the shortage of insufficient land-use efficiency by improving labor production. (4) The change in labor force structure shows an “inverted U” trend with the degree of land fragmentation. When the old labor force reaches a certain point, land integration is promoted to reduce the degree of land fragmentation.

Due to the limited data and the location of the garlic planting being in the main garlic-producing area of Lanling County in Shandong Province, China, the generalizability of planting in labor-intensive industries has yet to be verified. Later, crops from different

planting areas and other labor-intensive industries will be added for verification in order to obtain a more complete theoretical model.

The research conclusions show that, according to the differences in labor force structure, garlic growers have different ways of improving land-use efficiency under different labor aging-rate scenarios. For land distribution, when the labor force aging degree is low, land transfer can maximize land-use efficiency, and when the aging degree of the labor force is high, farmers choose to transfer all land to promote land integration to make up for the impact of labor shortages. With the shortages of agricultural labor force and the pressure of aging increasingly serious, increasing labor input to develop intensive farming and diverse planting operations is unsustainable. Therefore, it can be seen that the relative concentration of land and specialized production is an inevitable way to improve land-use efficiency, but farmers still need to perform planting structure adjustments due to the efficiency loss caused by path dependence and the crushing configuration imbalances in planting adjustments. For this purpose, this paper proposes the following recommendations:

- (1) Promote comprehensive land improvement in Lanling County in Shandong Province with high quality. Combined with policy projects, such as linking increase and decrease, land consolidation, high-standard farmland construction, and small-scale farmland water conservancy, strengthen the comprehensive transformation and improvement of rural roads, water, fields, forests, and nets, focusing on improper allocation, unreasonable utilization, and scattered, idle land. Concentrated remediation and in-depth development of underutilized plots will effectively improve farmland infrastructure and agricultural production conditions.
- (2) Guide garlic growers to voluntarily carry out the mutually beneficial exchange of contracted land. On the premise of adhering to the household contract system and keeping the original total land contracted area of farmers unchanged and in accordance with the principle of the farmers' voluntary, equal, and mutual benefit, guide and help farmers to integrate and merge the scattered land through exchange so as to realize consolidation of fragmented and scattered contracted land into relatively concentrated, large plots.
- (3) Encourage the development of garlic agriculture on an appropriate scale. Focusing on the two paths of land scale and service scale, flexibly use new models and new formats, such as professional cooperation, share cooperation, land transfer, land investment, land trusteeship, joint farming, and joint cultivation, to guide the small-scale and fragmented land management mode to intensive, professional, large-scale and mechanized transformations.
- (4) Encourage garlic farmers to carry out diversified planting in order to reasonably arrange different products in different plots, smooth the input of factors over time, and reduce the difficulty of management. Guide knowledgeable young people to join agriculture through policy support, promote labor-saving technologies based on the needs of farmers, hire elderly laborers with rich agricultural experience to promote localized experience and skills, and include the elderly labor force to prevent waste.

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References

- Long, H.; Tu, S.; Ge, D.; Li, T.; Liu, Y. The allocation and management of critical resources in rural China under restructuring: Problems and prospects. *J. Rural Stud.* **2016**, *47*, 392–412. [[CrossRef](#)]
- Rones, P.L. The aging of the older population and the effect on its labor force rates. *J. Mon. Labor Rev.* **1982**, *105*, 27–29.
- Hitoshi, A. Mechanisms of sustaining agriculture and the aging of rural communities in Takamiya-cho, Hiroshima Prefecture. *J. Geogr. Rev.* **2002**, *75*, 262–279.
- Li, M.; Sicular, T. Aging of the labor force and technical efficiency in crop production: Evidence from Liaoning province, China. *J. China Agric. Econ. Rev.* **2013**, *5*, 342–359. [[CrossRef](#)]
- Li, Z.H. Analysis on the nature and characteristics of population aging—And on over-aging population. *J. Res. Aging* **2013**, *2*, 3–10.
- Qiao, Z.X.; Lin, B.X. Effects of aging agricultural labor force on land use efficiency. *J. South China Agri. Uni.* **2017**, *5*, 61–73.
- Lin, B.X.; Deng, H.S. An Empirical Analysis of the Impact of Agricultural Labor Ageing on Land Use Efficiency—Based on Data from Fixed Observation Points in Zhejiang Rural Areas. *J. China Rural Econ.* **2012**, *4*, 15–25.
- Liu, H.Y.; Hao, H.G.; Li, Y.Y. Livelihood Diversification of Farm Households and Its Impact on Cultivated Land Utilization in Agro-pastoral Ecologically-vulnerable Areas in the Northern China. *Chin. Geogr. Sci. J.* **2020**, *30*, 279–293. [[CrossRef](#)]
- Yang, Z.H.; Li, P.; Wang, Y.P. Influence of the aging of rural labor force on farmland utilization efficiency of farmers. *J. Reg. Res. Dev.* **2015**, *5*, 167–171.
- Etienne, X.L.; Ferrara, G.; Mugabe, D. How efficient is maize production among smallholder farmers in Zimbabwe? A comparison of semiparametric and parametric frontier efficiency analyses. *Appl. Ecol.* **2019**, *51*, 2855–2871. [[CrossRef](#)]
- Yang, J.; Yang, G.G.; Hu, X.H. The influence of agricultural labor age on farmland utilization efficiency of farmers—Empirical evidence from regions with different economic development levels. *J. Resour. Sci.* **2011**, *6*, 1691–1698.
- Maina, F.; Mburu, J.; VanLeeuwen, J. Factors influencing economic efficiency of milk production among small-scale dairy farms in Mukurweini, Nyeri County, Kenya. *Trop. Anim. Health Prod.* **2020**, *52*, 533–539. [[CrossRef](#)] [[PubMed](#)]
- Zou, B.; Luo, B.L. Why the Uncertain Term Occurs in the Farmland Lease Market: Evidence from Rural China. *Sustainability* **2018**, *10*, 2813. [[CrossRef](#)]
- Xuejun, L.; Yanbing, M. Land fragmentation will inevitably lead to a decrease in land production efficiency Low?—Criticism of research on land fragmentation and land productivity Analysis. *J. Huazhong Agric. Univ. Soc. Sci. Ed.* **2013**, *6*, 109–115.
- Yueqing, J.; Xingbai, X.; Hua, L. Land Fragmentation and Rural Labor Transfer Research. *J. Chin. Popul. Resour. Environ.* **2016**, *26*, 105–115.
- Qing, X.; Shichao, T.; Zhigang, X.; Ting, S. Farmland system, land fragmentation and farming people's income inequality. *J. Econ. Res.* **2008**, *2*, 83–92.
- Latruffe, L.; Piet, L. Does Land Fragmentation Affect Farm Performance? A Case Study from Brittany, France. *Agric. Syst.* **2014**, *129*, 68–80. [[CrossRef](#)]
- Manjunatha, A.V.; Anik, A.R.; Speelman, S. Impact of Land Fragmentation, Farm Size, Land Ownership and Crop Diversity on Profit and Efficiency of Irrigated Farms in India. *Land Use Policy* **2013**, *31*, 397–405. [[CrossRef](#)]
- Rahman, S.; Rahman, M. Impact of Land Fragmentation and Resource Ownership on Productivity and Efficiency: The Case of Rice Producers in Bangladesh. *J. Land Use Policy* **2009**, *26*, 95–103. [[CrossRef](#)]
- Zuhui, H.; Jianying, W.; Zhigang, C. Effects of off-farm employment, land transfer and land fragmentation on the technical efficiency of rice farmers. *J. Chin. Rural. Econ.* **2014**, *11*, 4–16.
- Chuanhao, T.; Honghui, C.; Shenghua, J. The influence of farmland market on the fragmentation of cultivated land—Theory and experience from Jiangsu, Zhejiang and Shandong. *J. Econ. Q.* **2005**, *2*, 769–784.
- Niroula, G.S.; Thapa, G.B. Impacts of land fragmentation on input use, crop yield and production efficiency in the mountains of Nepal. *Land Degrad. Dev.* **2007**, *18*, 237–248. [[CrossRef](#)]
- Balogun, O.L.; Akinyemi, B.E. Land fragmentation effects on technical efficiency of cassava farmers in South-West geopolitical zone, Nigeria. *Cogent Soc. Sci.* **2017**, *3*, 1387983. [[CrossRef](#)]
- Bentley, J.W. Wouldn't You Like to Have All of Your Land in One Place Land Fragmentation in Northwest Portugal. *J. Hum. Ecol.* **1990**, *18*, 51–79. [[CrossRef](#)]
- Niroula, G.S.; Thapa, G.B. Impacts and Causes of Land Fragmentation, and Lessons Learned from Land Consolidation in South Asia. *J. Land Use Policy* **2005**, *22*, 358–372. [[CrossRef](#)]
- Wenming, L.; Dan, L.; Jie, C.; Yan, X. Moderate scale operation in agriculture: Scale benefits, output levels and production costs—Based on the survey data of 1552 rice growers. *J. China Rural. Econ.* **2015**, *3*, 4–17.
- Yueqing, J.; Funing, Z. Non-agricultural employment and agricultural machinery service utilization of farmers. *J. Nanjing Agric. Univ. Soc. Sci. Ed.* **2013**, *5*, 47–52.
- Peng, D.; Wu, X. Research on China's agricultural technical efficiency and total factor productivity: Based on the perspective of rural labor force structure changes. *J. Econ.* **2013**, *9*, 68–76.
- Hu, X.; Zhong, F. The impact of the aging of the rural population on grain production: An analysis based on data from fixed observation points in rural areas. *J. China Rural Econ.* **2012**, *7*, 29–39.
- Guo, X.; Ren, Y.; Liao, Z.; Wang, X. The situation, impact and countermeasures of the aging of agricultural labor force in large agricultural province—Based on 501 farmer households in Sichuan Province investigation. *J. Financ. Sci.* **2014**, *4*, 128–140.

31. Hu, X.; Zhong, F. The impact of population aging on crop production: Based on the analysis of wheat and cotton crops. *J. Agric. Eco. Probl.* **2013**, *2*, 36–43.
32. Chen, X.; Chen, Y.; Jianjun, Z. A quantitative study on the impact of the aging of rural population in China on agricultural output. *J. Chin. J. Popul. Sci.* **2011**, *2*, 39–46.
33. Li, M.; Zhao, L. The phenomenon of “aging” of the agricultural labor force and its impact on agricultural production—An empirical analysis based on Liaoning Province. *J. Agric. Econ. Issues* **2009**, *10*, 12–18.
34. Thiede, B.C.; Brown, D.L.; Sanders, S.R.; Glasgow, N.; Kulcsar, L. A Demographic Deficit? Local Population Aging and Access to Services in Rural America, 1990–2010. *Rural Sociol.* **2017**, *82*, 44–74. [\[CrossRef\]](#)
35. Bashir, M.K.; Ali, A. Estimation of economic and production efficiency of potato production in central Punjab, Pakistan. *J. Custos Agronegocio Line* **2021**, *17*, 2–23.
36. Liu, Y.; Huang, J. Multi-objective Planting Decision Model of Farmers and Estimation of Objective Weights. *J. Econ. Res.* **2010**, *45*, 148–157.
37. Luo, B.; Jiang, X.; Li, S.; Qiu, T. Will the transfer of farmland lead to the “non-grain” of the planting structure? *J. JH Acad. J.* **2018**, *2*, 94–101.
38. Gao, J.; Song, G.; Sun, X. Does labor migration affect rural land transfer? Evidence from China. *Land Use Policy* **2020**, *9*, 105096. [\[CrossRef\]](#)
39. Hua, L.; Hao, H. Analysis of the Impact of Land Fragmentation and Planting Diversification on the Profit and Efficiency of Agricultural Production—Based on a Micro-Investigation of Farmers in Jiangsu. *J. Agric. Technol. Econ.* **2015**, *7*, 4–15.
40. Zhong, F. Correct understanding of food security and agricultural labor costs. *J. Agric. Econ. Issues* **2016**, *37*, 4–9.
41. Su, Y.Q.; Araral, E.; Wang, Y.H. The effects of farmland use rights trading and labor outmigration on the governance of the irrigation commons: Evidence from China. *Land Use Policy* **2020**, *91*, 104378. [\[CrossRef\]](#)
42. Ntinhinyurwa, P.D.; de Vries, W.T. Farmland fragmentation and defragmentation nexus: Scoping the causes, impacts, and the conditions determining its management decisions. *Ecol. Indicators* **2020**, *119*, 106828. [\[CrossRef\]](#)
43. Fang, C. The End of the Era of Unlimited Supply of Labor. *J. Financ. Econ.* **2008**, *3*, 2014.
44. Schultz, T.W. *The Economic Organization of Agriculture*; McGraw-Hill Book Company Inc.: New York, NY, USA, 1953.
45. Kalantari, K.; Abdollahzadeh, G. Factors Affecting Agriculture Land Fragmentation in Iran: A Case Study of Ramjerd Sub district in Fars Province. *Am. J. Agric. Biol. Sci.* **2008**, *3*, 358–363.
46. Tan, S.; Heerink, N.; Kuyvenhove, A. Impact of Land Fragmentation on Rice Producers’ Technical Efficiency in South-East China. *NJAS-Wagen J. Life Sci.* **2010**, *57*, 117–123. [\[CrossRef\]](#)
47. Peiyong, C.; Fengbo, C. Research on the Causes and Influences of Land Fragmentation Review. *J. China Land Sci.* **2011**, *25*, 90–96.
48. Meng, T.; He, X. China’s Farmland Fragmentation and Its Governance. *J. Jiangxi Univ. Financ. Econ.* **2015**, *2*, 88–96.
49. Zhan, J.; Zhang, Y.; Zhang, Z. Does land fragmentation hinder the development of outsourcing services in rice productive links? *J. Nanjing Agric. Univ.* **2016**, *16*, 117–124.
50. Haji, J. Production efficiency of smallholders’ vegetable-Dominated mixed farming system in Eastern Ethiopia: A non-parametric approach. *J. Afr. Econ.* **2007**, *16*, 1–27. [\[CrossRef\]](#)
51. Tan, S.; Heerink, N.; Kruseman, G. Do fragmented landholdings have higher production costs? Evidence from Rice farmers in Northeastern Jiangxi Province. *China Econ. Rev.* **2008**, *19*, 347–358. [\[CrossRef\]](#)
52. Hua, L.; Hao, H. Does Land Fragmentation Increase the Cost of Agricultural Production? A Micro Survey from Jiangsu Province. *J. Econ. Rev.* **2015**, *5*, 129–140.
53. Guo, G.; Ding, C. A Quantitative Study on the Impact of Land Fragmentation on the Return to Scale of Grain Production—Based on the Empirical Data of Yancheng City and Xuzhou City, Jiangsu Province. *J. Nat. Resour.* **2016**, *31*, 202–214.
54. Li, Y. An Empirical Study of Farmers’ Perception & Behavior on Farmland Abandonment in Yunnan Province. *J. Asian Agric. Res. Engl. Version* **2017**, *5*, 63–65.
55. Liu, Z.M.; Zhang, L.; Feng, S.Y. Do land markets improve land-use efficiency? Evidence from Jiangsu, China. *Appl. Econ.* **2019**, *25*, 317–330. [\[CrossRef\]](#)
56. Wan, G.H.; Cheng, E. Effects of Land Fragmentation and Returns to Scale in the Chinese Farming Sector. *Appl. Econ.* **2001**, *33*, 183–194. [\[CrossRef\]](#)
57. Fleisher, B.; Liu, Y.H. Economies of scale, plot size, human capital and productivity in Chinese agriculture. *J. Quart. Rev. Econ. Financ.* **1992**, *32*, 112–123.
58. Qiu, T.W.; Luo, B.L. Do land renting-in and its marketization increase labor input in agriculture? Evidence from rural China. *Land Use Policy* **2020**, *99*, 104820.
59. Zhao, Q.Y.; Bao, H.X.H.; Zhang, Z.L. Off-farm employment and agricultural land use efficiency in China. *Land Use Policy* **2021**, *101*, 105097. [\[CrossRef\]](#)
60. Shuilian, W.; Xian, X. Does land fragmentation hinder the mechanization of sugarcane cultivation? *J. China Rural. Econ.* **2017**, *2*, 16–29.
61. Tao, L.; Futian, Q.; Jing, J.; Xiaoping, S. Effects of land fragmentation and land transfer on farmers’ land use efficiency. *J. Resour. Sci.* **2008**, *10*, 1511–1516.
62. Hong, Y.; Heerink, N. Intercropping contributes to a higher technical efficiency in smallholder farming: Evidence from a case study in Gaotai County, China. *Agric. Syst.* **2019**, *173*, 317–324. [\[CrossRef\]](#)

-
63. Wen, Z.; Ye, B. Analysis of Mediating Effect: Method and Model Development. *J. Adv. Psychol. Sci.* **2014**, *22*, 731–745. [[CrossRef](#)]
 64. Edwards, J.; Lambert, L.S. Methods for Integrating Moderation Mediation: A General Analytical Framework Using Moderated Path analysis. *Psychol. Methods* **2007**, *12*, 1–22. [[CrossRef](#)] [[PubMed](#)]
 65. Qinghua, S. *Research on Sustainable Economic Development of Farmers: Changes of Thousands of Ten Villages in Zhejiang (1986–2002)*; China Agricultural Press: Beijing, China, 2005.