Study on the Causes of Differences in Cropland Abandonment Levels among Farming Households Based on Hierarchical Linear Model —— 13120 Farming Households in 26 Provinces of China as an Example

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Study on the Causes of Differences in Cropland Abandonment Levels among Farming Households Based on Hierarchical Linear Model——13120 Farming Households in 26 Provinces of China as an Example

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Abstract: Cropland abandonment is a widespread phenomenon with an increasing trend around the world, including China. Cropland abandonment is the result of a multi-scale and multi-factor nested structure, in order to comprehensively identify the individual and background effects, the study explores the causes of the differences in farmland abandonment levels at two levels: farm household and village, based on a hierarchical linear model. The results show that: (1) 83.63% of the differences in farm abandonment rates are differences in farm households while 16.37% are differences in their villages; (2) whether head of household is healthier, per capita cropland area, ratio of transferred farmland, possession of large-scale agricultural production machinery or livestock for agricultural production, ratio of agricultural income, and whether there are village cadres have a significant negative impact on abandonment rates at the farm household level; while at the village level, commuting distance, whether it is a suburb of a large or medium-sized city, topography of the village is plain or not, and ratio of the number of people in agricultural production in the village have a significant positive impact on abandonment rates, while whether it has experienced land expropriation has a significant positive effect on the abandonment rate; (3) commuting distance weakens the negative correlation between the ratio of transferred cropland and the ratio of agricultural income and the abandonment rate; whether it is a suburb of a large or medium-sized city strengthens the negative correlation between whether it owns large-scale agricultural production machinery or livestock and the abandonment rate; whether the topography of the village is plain weakens the negative correlation between the possession of large agricultural production machinery or livestock for agricultural production and the agricultural income ratio and the abandonment rate; ratio of the number of people in agricultural production in the village weakens the negative correlation between the ratio of transferred cropland and abandonment rate; and whether the village has experienced land expropriation strengthens the negative correlation between the ratio of agricultural income and abandonment rate.

Keywords: cropland abandonment; hierarchical linear model; background effect; causal analysis; China

1. Introduction

Since the 20th century, cropland abandonment has been seen worldwide due to the impacts of migration of agricultural activities, declining net land revenues, land system reforms and agricultural policy adjustments [1]. In recent years, cropland abandonment has intensified worldwide due to factors such as the rampant global new crown epidemic, changes in the international trade situation of agricultural products, and the frequent occurrence of extreme disasters and weather [2]. Since the 1980s, cropland abandonment has been gradually highlighted in China, and with the deepening of urbanization and industrialization, the agricultural labor force continues to precipitate, and the phenomenon has also shown a trend of intensification [3]. According to statistics, in 2011 and 2013,

13.5% and 15% of China's agricultural land was idle, respectively [4]. Cropland abandonment is a common problem faced by the whole world, which has become an important direction of land use/cover research (*LUCC*) [3], studying and solving this problem is conducive to the maintenance of food security and the realization of long-term sustainable development, which is even more significant for China, a populous country.

In order to effectively solve the problem of cropland abandonment, domestic and foreign academics have been from the perspective of agronomy, ecology, geography, agroforestry economics and other perspectives [5], around the connotation of cropland abandonment, causes, impacts and countermeasures to carry out a wealth of research [3,5,6], the causes of cropland abandonment as an important part of the study of the cropland abandonment, for the scientific understanding and effective solution to the problem of the practice and theory of great significance. Reviewing the research on the causes of the current situation of cropland abandonment, it can be summarized from the three aspects of the formation causes and influencing factors, research scales and research methods: First, the formation causes and influencing factors, cropland abandonment is the result of the integrated effect of economic development [6–8], policy system [9–12], technological development [13,14], natural ecology [15–18] and other driving forces, and the socio-economic reasons are dominant [3,18]. Among them, the marginalization of cropland and the withdrawal of agricultural labor force caused by urbanization and industrialization are the root cause [3,19] and the direct cause [3,6,20] of the formation of cropland abandonment phenomenon, respectively. Cropland abandonment influencing factors are subordinate to the formation of causes, which are the specific paths of various causes, and the identification of influencing factors can help to understand the causes of cropland abandonment [3]. In conjunction with the causes, the academic community to determine the type of factors as a criterion to determine the factors affecting the abandonment of cropland, quite representative and general is the viewpoint of Li and others, the factors affecting the social and economic conditions, agricultural production conditions, labor force characteristics of the three categories [3]. Specifically, socio-economic conditions include: agricultural inputs [21–24], household income [25–27], policy system [28–31] and other socio-economic conditions [32–34]; labor force characteristics cover: labor force quantity [35–37], labor force quality [38,39] and other labor force characteristics [40,41]; and agricultural production conditions can be categorized into: natural production conditions [42–45] and social production conditions [46–49]. Second, the research scale can be divided into observation scale and explanatory scale [50], and most of the existing studies at home and abroad are based on one or some explanatory scale to explore the causes of cropland abandonment in one or more regions. From the perspective of observational scale, domestic scholars mostly focus on smaller spaces such as counties, townships and villages [51–54], while foreign scholars focus more on larger spaces such as countries and regions [26,27,31,55]; from the point of view of explanatory scale, domestic and foreign scholars are inclined to villages, farmers and plots of land and other relatively microscopic scales [23,44,53,56–58]. Third, the research methodology is diversified, and most of the existing studies in the academic community are based on primary, secondary or mixed data, and use one or more qualitative or quantitative research methods to explore the causes of cropland abandonment according to the way of cropland abandonment level measurement. Specifically, qualitative methods include field survey method [44,59], literature analysis method [60,61], and qualitative comparative analysis (QCA) [62], etc.; quantitative methods include binary (or multiple-valued) Logit model [20,21,27,48], Tobit model (and its extension) [22,32], and Probit model [32,43], OLS model (and its extensions) [37,52], geographically weighted regression model [37,63], optimal subset regression model [12,41], (augmented) regression tree model [24,34] and (generalized) hierarchical linear model (HLM) [64,65].

To summarize, existing research results in the academic community generally indicate that cropland abandonment is the result of the combined effects of multi-scale and multi-factors [3]. However, under the influence of natural resource endowment and socio-economic development, the degree of farmland abandonment of different farm households in the same village is generally more similar than that of randomly selected farm households in different villages; in the same farm household, the abandonment decisions of family members tend to be more similar than those of family members in different farm households [64,65]. Therefore, the phenomenon of cropland

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abandonment is more the result of the nested structure of influences at different scales, with a multilevel data structure. Nevertheless, most of the existing cause studies in the academic world have neglected the nested structure of the cropland abandonment data, mostly based on the traditional regression analysis method to analyze the cause of cropland abandonment from the individual level, and directly combined the data from different groups, and this kind of analytical thinking has neglected the influence of the background effect on the individual [66,67], the so-called background effect refers to the nested structure of the data in the social sciences research, and the role of the relationship between the variables of the inter-level variables [67,68], which makes a lot of the differences that were originally brought about by the subgroups are interpreted as the individual's difference, and the resulting conclusion of the causes of the abandonment of the cropland abandonment is not scientifically accurate. Hierarchical linear model is a statistical analysis method used to analyze data with a nested structure, and its emergence effectively solves the problem of solving the background effect [67,69]. A few scholars have also explored the causes of cropland abandonment using hierarchical linear models. Zhang and others [64] used a generalized hierarchical linear model to analyze the impacts of three levels of factors, namely plot, household, and village, on the cropland abandonment phenomenon in Wulong County of Chongqing Municipality, and Jiang and others [65] explored the impacts of the factors of the household and county levels on the cropland abandonment phenomenon in 14 provinces in China based on a hierarchical linear model. Although the analysis based on hierarchical linear model is better than the traditional analysis method, the above studies also have certain shortcomings, first, the degree of explanation of the background effect is insufficient, and they did not analyze the interaction between the factors at each level, especially the influence of high-level factors on the slope of the factors at the lower level; second, the scope of the study needs to be further expanded, and the representativeness and generality of the conclusions obtained are limited. It can be seen that the problem of abandonment of cropland, which is related to food security, should be given special attention in China on a continuous basis.

To conclude, with the purpose of effectively solving the problem of farmland abandonment, and based on the achievements and shortcomings of the existing achievements of domestic and foreign academics, this study, based on the multi-period CLDS data, adopts a hierarchical linear model to investigate the causes of cropland abandonment in 26 provinces of China at the levels of farmers and villages, and focuses on identifying the individual effects and the background effects, in order to obtain a more scientific and general conclusion on the causes of cropland abandonment.

2. Theoretical Analysis and Research Hypotheses

2.1. Theoretical Analysis

2.1.1. The ""Rational Man"" Hypothesis and Cropland Abandonment

The "rational man" assumption is one of the most basic assumptions of economics, which is the cornerstone of the entire economic theory [70], and can effectively explain why farmers choose to abandon their farmland.

According to the "rational man" hypothesis, every individual is a "rational man", and farmers are no exception, whose biggest goal is to maximize their own interests, with the same motivation as that of the micro subjects of the market economy [28]. As a "rational person", farmers weigh the long-term and short-term interests and risk factors to make decisions in order to maximize the benefits [71]. Therefore, when the benefits of agricultural production cannot be maximized, farmers will gradually leave the field. The damage of maximizing the benefits of agricultural production is closely related to the impact of urbanization and industrialization, changes in market demand, fluctuations in agricultural prices, adjustments in agricultural policies and systems, and advances in agricultural technology [3]. Among them, the promotion of urbanization and industrialization plays the most obvious role, and its various impacts can effectively explain the phenomenon of farmland abandonment.

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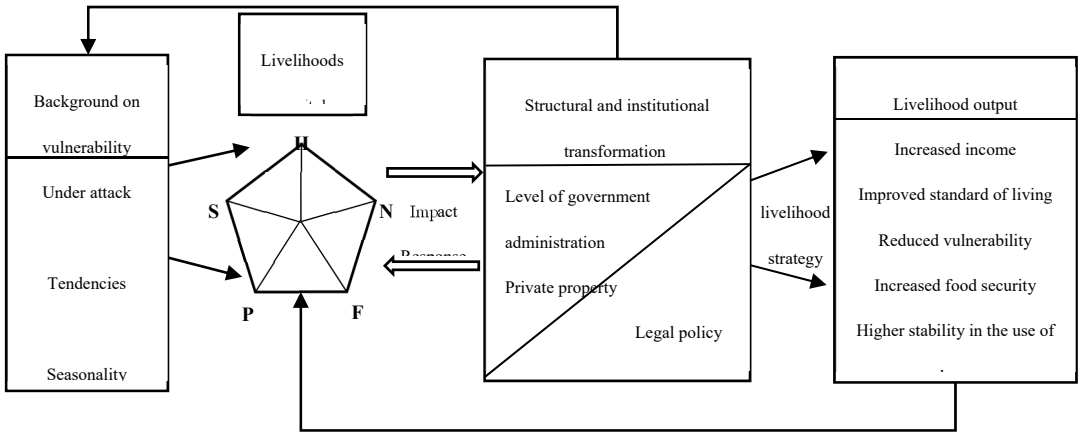
On the one hand, the advancement of urbanization and industrialization will lead to the marginalization of cropland, which is the root cause of cropland abandonment and an important driving force for farmers to choose cropland abandonment. The so-called marginalization of cropland, that is, when a piece of cropland has only one alternative use, due to changes in production costs and income, the profit of the cropland falls to zero or negative, that is, the cropland is outside the no-rent margin; and no matter how the farmers adjust the inputs of factors of production of the cropland is outside the no-rent margin, then as a "rational person", the farmers will choose not to operate this cropland. Then the farmer as a "rational person" chooses not to operate this piece of farmland, resulting in the abandonment of farmland [3]. The advancement of urbanization and industrialization will mainly bring changes in labor factors, which provide non-farm employment opportunities and increase non-farm income, making the price of agricultural labor rise rapidly, resulting in the increase of the cost of farming, thus compressing the profitability of agricultural production, so that farmers can not continue to maximize the benefits of engaging in agricultural production, and turn to the non-farm employment field.

On the other hand, the process of urbanization and industrialization provides the possibility and opportunity for farmers to maximize their benefits in non-farm employment, which further exerts a pull on farmers to choose to leave their farmland abandoned. With the massive influx of rural population into the cities, the livelihood strategy of farm households has gradually changed to part-time employment and non-farming, and the maximized benefits they can obtain are specifically manifested in both economic and non-economic gains [70]. From the point of view of economic gain, generally speaking, the part-time and non-farming livelihood strategy has higher economic gain compared with traditional agriculture, and can realize the maximization of economic gain; from the point of view of non-economic gain, due to the long-term existence of the urban-rural dichotomous structure, there is a big difference between urban and rural areas in terms of the social security system, health care conditions, and educational resources, etc. [72], the rural households from the countryside to the city, and they also can enjoy the more superior living conditions in the city and maximize non-economic gains.

2.1.2. The Sustainable Livelihoods Analytical Framework and the Cropland Desertification Phenomenon

The sustainable livelihood analysis method has been widely used in related research in many fields as well as deriving diversified sustainable livelihood analysis frameworks, among which, the Sustainable Livelihoods Framework (SLA) proposed by the UK Department for International Development (DFID) is used relatively frequently [73,74].



（H: Human Capital, N: Natural Capital, F: Financial Capital, P: Material Capital, S: Social Capital）

Figure 1. DFID Sustainable Livelihoods Analytical Framework.

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The framework consists of five components: vulnerability background, structural and institutional change, livelihood capital, livelihood strategy and livelihood output [75–78], which provides a theoretical basis for exploring the influencing factors that farmers consider when choosing to abandon their farmland.

From the analysis of the "rational man" hypothesis, it can be seen that, as one of the livelihood strategies of farmers, there is a motivation to maximize the benefits behind the choice of farmland abandonment. However, from the perspective of the sustainable livelihood analysis framework, the adjustment of the livelihood strategy of farmers cannot be arbitrary, but is determined by the status of their livelihood capital [74]. The advancement of urbanization and industrialization, changes in market demand, and fluctuations in agricultural prices are essentially part of the vulnerability background and structural and institutional shifts in the framework of sustainable livelihoods, which are uniformly defined in this study as exogenous shocks, which, while leading to the failure to maximize the returns from agricultural production, also have an impact on various types of livelihood capitals of the farm households, and thus affect the choices of their livelihood strategies.

At the meanwhile, the choice of farmland abandonment is not only stimulated by their own livelihood capital, but also by the influence of external natural and socio-economic factors [74]. Nevertheless, most of the existing studies based on the framework of sustainable livelihood analysis to explore the factors influencing livelihood strategies have ignored the external environmental context or confused it with livelihood capital [73], and the conclusions obtained are not comprehensive and accurate. In view of this, this study extends and improves the status quo sustainable livelihood analysis framework by analyzing the external environmental background faced by farmers when choosing whether to leave their farmland abandoned or not, which can be categorized into two types: first, the external shocks consisting of the vulnerability background and the structural and institutional shifts; and second, the characteristics of the village that have the most direct and close relationship with the farmers. China is the world's largest developing country, in order to ensure food security and achieve long-term sustainable development, cropland protection and agricultural production have always been highly valued by the party and the state, the vulnerability background and structural and institutional changes faced by farmers in the process of agricultural production are basically the same in all regions [79]; and villages, due to the relatively microscopic spatial scale, have obvious differences in the natural geographic features and socio-economic features and are easy to recognize. Therefore, this study analyzes village characteristics as specific variables, and the purpose of exploring external shocks is mainly to make the theoretical analysis relatively complete.

In summary, when choosing whether or not to leave farmland abandoned, farmers should consider their own livelihood capital and village characteristics comprehensively. It has been shown that farmers are nested within villages, and the data on cropland abandonment has a nested structure, therefore, the impacts of farmers' livelihood capital and village characteristics on farmers' choice of cropland abandonment have both individual and background effects, and it is necessary to pay attention to the independent impacts of the factors at each level as well as analyze the interactions of the factors at different levels, and in this study, we focus on the moderating effect of the village-level factors on the impacts of the factors at the farmer level on the cropland abandonment. This study focuses on the moderating effect of village-level factors on the impact of farm household-level factors on cropland abandonment.

2.1.3. Theoretical Analysis Framework

By integrating the "rational man" hypothesis and the sustainable livelihood analysis framework with the relevant content of farmland abandonment, the theoretical analysis framework is constructed by focusing on the individual and background effects of factors at the household and village levels that farmers consider when choosing whether or not to abandon their farmland.

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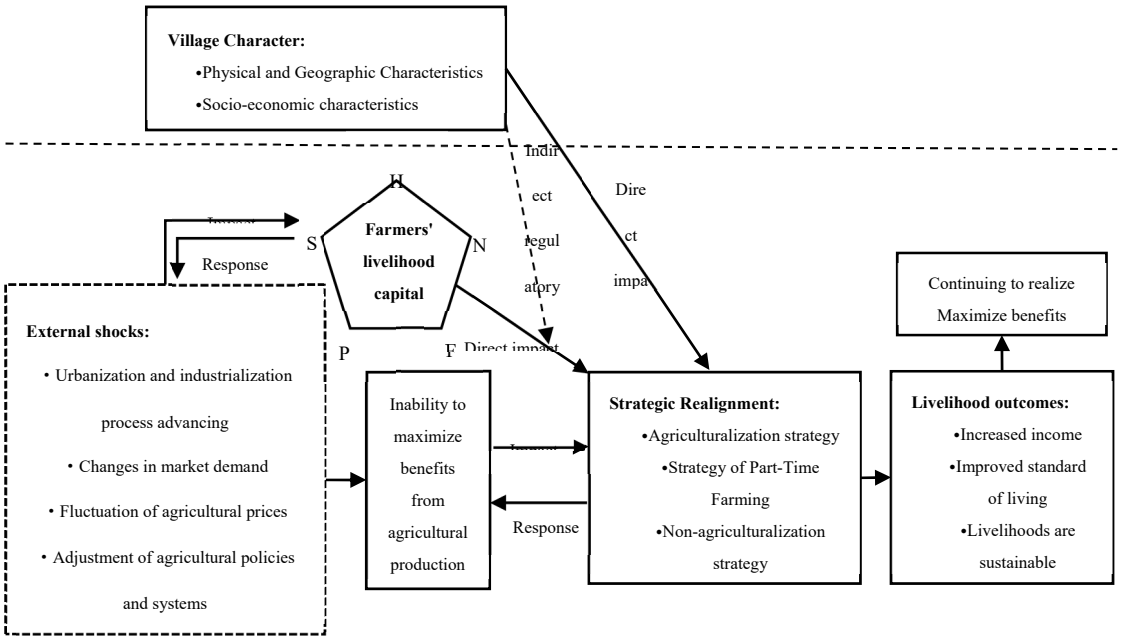

Note: The external shocks in the dashed box are intended to make the theoretical analysis of farm household cropland abandonment behavior

Figure 2. Theoretical analysis framework.

The analytical framework shows that in the face of external shocks that prevent agricultural production from continuing to maximize benefits, farmers, as "rational beings", will adjust their livelihood strategies and shift from traditional agriculture to part-time farming and off-farming, in order to achieve the expected livelihood outcomes and continue to maximize their benefits. However, the process by which farmers adjust their livelihood strategies in order to continue to maximize their benefits is not random; on the one hand, it is influenced by their own livelihood capital, which changes as a result of external shocks; on the other hand, it is also important to take into account the role of external factors, and this study focuses on analyzing the relevant factors at the village level, which is the level that is the most closely related to the farmers. Finally, whether farmers choose to abandon their farmland or not is the result of the nested structure of influencing factors at the farmer and village levels, and when considering the specific influence of factors at each level, it is not possible to analyze them at the same level, and it is necessary to fully identify their individual and background effects, and to explore the moderating effect of village-level factors on the influence of farmer-level factors on cropland abandonment on the basis of clarifying the influence of factors at each level on cropland abandonment.

2.2. Research Hypotheses

Whether or not farmers choose to leave their cropland abandoned is the result of a nested structure of factors at both the farmer and village levels. In light of this, this study uses a hierarchical linear model to decompose the within-group and between-group variation in the level of cropland abandonment, to identify individual and background effects in the formation of this problem, and to clarify the influence of factors at each level on the differences in the level of cropland abandonment, and the influence of factors at the village level on the driving force of factors at the household level, with the aim of obtaining more scientific and comprehensive conclusions about the causes of the phenomenon. In conclusion, this study proposes the following three research hypotheses:

H1: Differences in the level of farmland abandonment of farm households can be decomposed into differences in farm households and differences in villages, and are dominated by differences in farm households;

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H2: All five types of livelihood capital of farm households have characterizing factors that have a significant effect on the differences in the level of cropland abandonment, and there is village heterogeneity in the role of some of the capital's characterizing factors;

H3: Both types of village characteristics have characterizing factors that have a significant effect on differences in the level of cropland abandonment, and they moderate the effect of characterizing factors for the livelihood capital of farm households where village heterogeneity exists.

3. Data Sources and Research Methodology

3.1. Data Sources and Processing

3.1.1. Data Source

The data for this study come from the China Labor Dynamics Survey Database (CLDS), which is constructed under the auspices of the National Development Research Institute of Sun Yat-sen University, and currently has four issues of data published for the years 2012, 2014, 2016 and 2018, covering the three levels of the individual, the household and the village, and the samples cover 29 provinces and municipalities in China, which is of a certain degree of scientific validity, authoritativeness, comprehensiveness and national representativeness [80].

3.1.2. Data Processing

According to the purpose of the study, this study selected three periods of data in 2014, 2016 and 2018, mainly using the household and village residence questionnaires, and based on the screening of the required variables, the three years of data were combined into unbalanced panel data and processed with the help of Stata16.0 and SPSS22.0 software, totaling 40,751 samples. The specific processing process includes: (1) retaining the samples that live in rural areas and the head of household is an agricultural household while contracted with cropland; (2) deleting the samples that exist in the cases of inapplicability, lack of clarity, and refusal to answer, etc.; (3) deleting the samples that don't conform to the significance of economics, which are mainly the samples that have negative incomes in various categories; (4) deleting the samples that have the head number of the household is missing and decomposing the remaining samples into the two datasets of farm households and villages ; (5) deal with the missing values in the dataset, as the maximum missing proportion of both datasets is less than 10%, the mean interpolation method is used to interpolate the missing values, in which the continuous indicators are interpolated using the mean of the series, and the discrete indicators are interpolated using the plurality of numbers [81]; (6) shrink the tail of the continuous indicators in the two datasets, to exclude the impact of outliers on the regression results; (7) generate the proportion indicators required for the study, and exclude the samples that do not have economic significance, such as the proportion greater than 1, etc.; at the same time, logarithmic treatment is applied to the income and expenditure indicators to improve the accuracy of the regression results; (8) based on the village number, the data sets of farm households and villages are re-matched to form the final data set, covering 13,120 farm households, 645 villages, 26 provinces, and the data are nationally representative.

3.2. Variable Identification and Indicator System

3.2.1. Explained Variables

To measure cropland abandonment, there are two types of variables commonly used in academia, discrete and continuous, of which the discrete variable is whether or not to abandon the cropland; and the continuous variable is the area of abandonment and the rate of abandonment of cropland. In this study, we believe that the use of the dummy variable of whether to abandon or not to abandon reflects the abandonment behavior of farm households, which will lose a lot of important information [32]; at the same time, there is a significant difference in the size of the cultivated area in each region, and the abandonment area ignores the positive correlation between the number of

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abandoned areas and the total area of cropland, which is also insufficient for this measurement. In light of this, in order to more accurately measure the phenomenon of cropland abandonment, the abandonment rate, i.e., the ratio of the area of cropland left abandoned by households to the total area of cropland in the household, was selected as the explanatory variable in this study.

3.2.2. Explanatory Variables

(1) Farm household level (*Level-1*) explanatory variables

Based on the livelihood capital in the sustainable livelihood analysis framework, this study selects farm household level explanatory variables from the five aspects of human, natural, physical, financial and social capital, taking into account existing research and data availability. ①Human capital: covering the quantity and quality of labor, this study selects the size of the household to characterize the quantity of labor; the head of the household, as the head of the family, has an important influence on the choice of household livelihood strategies, and selects whether the head of the household has a high school education or higher and whether the head of the household is physically healthier to characterize the quality of labor. ②Natural capital: the focus is on tangible productive capital, mainly cropland resources, which is the objective object of abandonment. This study analyzes the quantity and quality of cropland, of which the per capita area of cropland and the ratio of transferred cropland characterize the quantity of cropland, and whether there is pollution of cropland characterizes the quality of cropland. ③Physical capital: This includes infrastructure and public services and means of production. In China, the government sector, as the main provider of infrastructure and public services, strongly guarantees that farmers can enjoy basically the same infrastructure and public services in each region. Therefore, this study focuses on the means of production of farm households, which are characterized by whether they own large-scale agricultural production machinery used for agricultural production or whether the number of livestock and household durable goods reaches five or more types. ④Financial capital: mainly examining the inflow of funds, in order to more accurately and comprehensively reflect the inflow of funds to the farm household, this study from the per capita and the proportion of the two dimensions, the total annual income of the family per capita, agricultural income and non-agricultural income of the three aspects of the logarithm of the total annual income of the family per capita, the share of agricultural income and non-agricultural income accounted for the proportion of the three indicators were selected. ⑤Social capital: mainly derived from social organizations and social networks, in this study, the participation in social organizations is characterized by whether or not there is a village in the ministry, and the logarithm of annual human expenditure and whether or not they use the Internet are selected to characterize social networks.

(2) Village level (*Level-2*) explanatory variables

In this study, village-level explanatory variables were selected from the aspects of natural geographic characteristics and socio-economic characteristics. ①Physical geographic characteristics: mainly reflecting the topography and location of the village, covering three indicators: commuting distance, whether it is a suburb of a large or medium-sized city, and the topography of the village. ②Socio-economic characteristics: emphasize the industrial development and policy implementation of the village, including the ratio of the number of agricultural producers in the village, the presence of non-agricultural enterprises, whether the implementation of agricultural services and whether the village has experienced land expropriation.

3.2.3. Indicator System

Based on the results of variable identification, the indicator system of the causes of cropland abandonment is constructed. At the same time, according to the existing research in the academic world, combined with its own data characteristics and the actual situation, this study predicts the direction of the role of the variables.

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Table 1. Indicator system of causes of cropland abandonment.

Level	Variable Type	Variable Group	Variable Name and Symbol	Variable Definition and Assignment	Intended Effect
Farm household level	Explained variable		Abandonment rate *(QGZB)*	Proportion of land abandoned by farmers to total cultivated area(%)	
	Explanatory variable	Human capital	Do household heads have a high school diploma or higher *(EDU)*	No = 0; Yes = 1	+
			Whether the head of household is in relatively good health *(HEAL)*	No = 0; Yes = 1	-
			Household size *(JTRKGM)*	Sum of persons living with the family and persons away from the family (person)	-
		Natural capital	Cropland area per capita *(RJGDMJ)*	Ratio of area of cropland owned by households to total population size (acre/person)	-
			Ratio of transferred cropland *(ZRGDB)*	Proportion of area of cropland transferred by households to total area of cropland (%)	-
			Presence of contaminated cropland *(TRWR)*	No = 0; Yes = 1	-
		Physical capital	Ownership of large agricultural production machinery or livestock for agricultural production *(SCGJ)*	No = 0; Yes = 1	-
			Whether the number of types of durable goods in the household is five or more *(NYZL)*	No = 0; Yes = 1	+
		Financial capital	Total log annual household income per capita *(LNRJSR)*	Logarithm of the ratio of the sum of all types of household income in a year to the size of the household (yuan)	+
			Agricultural income ratio *(NYSRB)*	Share of annual household income from agriculture in total annual household income (%)	-
			Non-farm income ratio *(FNSRB)*	Household annual non-farm income as a share of total annual household income (%)	+
		Social capital	Availability of village cadres *(CGB)*	No = 0; Yes = 1	-

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			Log of annual expenditure on favours *(LNRQZC)*	Total household expenditure on gifts and gratuities in a year (yuan)	±
			Use of the Internet or not *(HLWQK)*	No = 0; Yes = 1	±
		Physical geographic characteristics	Commute distance *(TQJL)*	Distance of villages from township offices (kilometers)	-
			Whether it is a suburb of a medium-sized city *(DLWZ)*	No = 0; Yes = 1	+
			Topography of the village is plain or not *(CZDX)*	No = 0; Yes = 1	-
Village level	Explanatory variable		Number of village agricultural producers *(CZNYSCB)*	Percentage of people engaged in agriculture in villages compared to the total number of people in villages (%)	-
		Socio-economic characteristics	Availability of non-farm enterprises *(FNQY)*	No = 0; Yes = 1	+
			Whether or not to implement agricultural services *(HNFW)*	No = 0; Yes = 1	-
			Experiencing land expropriation or not *(TDZY)*	No = 0; Yes = 1	+

3.2.4. Descriptive Statistics of Variables

Descriptive statistics of the selected explained and explanatory variables were performed using HLM 6.08 software.

Table 2. Results of descriptive statistics of variables.

Variable Type	Variable Name	Sample Size	Mean	Standard Deviation	Min	Max
Explained variable	*QGZB*	13120	8.75	24.92	0.00	100.00
Farm household level explanatory variables	*EDU*	13120	0.09	0.29	0.00	1.00
	HEAL	13120	0.54	0.50	0.00	1.00
	JTRKGM	13120	5.17	2.75	1.00	15.00
	RJGDMJ	13120	1.68	2.58	0.02	50.00
	ZRGDB	13120	5.58	18.65	0.00	100.00
	TRWR	13120	0.49	0.50	0.00	1.00
	SCGJ	13120	0.12	0.32	0.00	1.00
	NYZL	13120	0.39	0.49	0.00	1.00
	LNRJSR	13120	8.39	1.21	0.18	12.21
	NYSRB	13120	36.85	42.70	0.00	100.00
	FNSRB	13120	39.77	44.09	0.00	100.00

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	CGB	13120	0.01	0.10	0.00	1.00
	LNRQZC	13120	5.39	3.65	0.00	9.90
	HLWQK	13120	0.41	0.49	0.00	1.00
	TQJL	645	5.68	5.22	0.00	30.00
	DLWZ	645	0.07	0.26	0.00	1.00
Village level explanatory variables	*CZDX*	645	0.41	0.49	0.00	1.00
	CZNYSCB	645	64.51	34.09	0.00	100.00
	FNQY	645	0.27	0.45	0.00	1.00
	HNFW	645	0.84	0.37	0.00	1.00
	TDZY	645	0.47	0.50	0.00	1.00

3.3. Hierarchical Linear Model

Conventional statistical regression analysis assumes that the variables are homogeneous and independent of each other, but in the case of nested data, the data used belong to different groups, so it is difficult to satisfy this condition, and the conclusions obtained from it have the problem of ignoring individual effects or background effects. The hierarchical linear model, which can scientifically analyze data with a nested structure and effectively identify individual and background effects, has been more successfully applied in the fields of education, psychology, health, and organizational management [82]. Therefore, it is reasonable to choose the hierarchical linear model to explore the causes of the differences in the level of cropland abandonment in this study, which includes four major sub-models, namely, the null model, the random-effects regression model, the intercept model, and the full model. The principle of this model to deal with nested structural data is as follows: the regression equation is first established with the explained variables and *Level-1* explanatory variables, after which the intercept and slope in the equation are used as the explained variables, and a secondary regression is carried out using *Level-2* explanatory variables, and this treatment can decompose the variance of the explained variables into the two parts of the within-group and between-group variance [67], and by decomposing the variance, the hierarchical linear model is able to distinguish between the individual effect and the background effect, and to reveal the relationship between the individual and the organizational variables. The basic form of the model is as follows:

***Level*-1 model:**

$$QGZB_{ij} = \beta_{0j} + \sum_{p=1}^{n} \beta_{pj} X_{pij} + \gamma_{ij} \quad (1)$$

***Level*-2 model:**

$$\beta_{pj} = \gamma_{p0} + \sum_{q=1}^{m} \gamma_{pq} W_{qj} + \mu_{pj}$$

In equation (1), i represents the farm household, j represents the village in which the farm household is located, n represents the number of *Level-1* explanatory variables, and p is the number of its values; m represents the number of *Level-2* explanatory variables, and q is the number of its values. $QGZB_{ij}$ is the abandonment rate, β_{0j} is the intercept of the regression of the *Level-1* explanatory variables on the explanatory variables, i.e., the average abandonment rate of farm households in the j_{th} village, X_{pij} denotes the p_{th} explanatory

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variable of *Level-1*, β_{pj} is its corresponding regression coefficient, and γ_{ij} is the stochastic component of *Level-1*; γ_{p0} denotes the intercept of the regression of *Level-2* explanatory variables on β_{pj}, i.e., the overall average of the abandonment rate of all the villages, γ_{pq} denotes the slope of the regression of *Level-2* explanatory variables on β_{pj}, W_{qj} denotes the q_{th} explanatory variable of *Level-2*, and μ_{pj} is the random component of *Level-2*.

4. Analysis of Empirical Results

4.1. Normality Test of the Explanatory Variables

The hierarchical linear model requires that the explained variables must satisfy the condition of obeying normal distribution, which is loosely approximated to satisfy the condition of obeying normal distribution [83]. Therefore, in this study, the skewness and kurtosis tests were chosen to test the normality of the abandonment rate with the help of SPSS 22.0 software.

Table 3 shows that the skewness value of 2.953 (standard error 0.021), Z-score = 2.953/0.021 = 140.619 and the kurtosis value of 7.420 (standard error 0.043), Z-score = 7.420/0.043 = 172.558. The skewness and kurtosis values are both >0 and the Z-score is not in the range of ±1.96, which indicates that the that the explanatory variables do not obey normal distribution. However, some studies in academia have shown that when the kurtosis is 7.420 less than 10 and the skewness is 2.953 less than 3, this indicates that the data is not absolutely normally distributed but basically acceptable as normal distribution [84], therefore the data is capable of stratification study.

Table 3. Results of normality test for explained variables.

Variable Name	Sample Size	Mean	Standard Deviation	Skewness		Kurtosis	
				Skewness value	standard error	Kurtosis value	standard error
QGZB	13120	8.751	24.924	2.953	0.021	7.420	0.043

4.2. Null Model

The so-called null model, which is a model with no explanatory variables in each level of the model, is the first step in the analysis of the hierarchical model, aiming to decompose the overall variance of the abandonment rate at the levels of farmers and villages, and to judge the necessity of the *Level-2* model. The specific form of the model is shown below:

***Level*-1 model:**

$$QGZB_{ij} = \beta_{0j} + \gamma_{ij} \quad (2)$$

***Level*-2 model:**

$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$

In Equation (2), the variables have the same meaning as in equation (1).

The results of model confidence estimation showed that the confidence of *Level-1* intercept was estimated to be 0.765, and the higher the confidence, the smaller the variance of the error, and the closer the estimated farm abandonment rate fitted by the model was to the actual abandonment rate. In general, if the model estimated confidence > 0.5, the model can be considered to basically meet the requirements [85]. Fixed effects showed that the overall mean of the abandonment rate for all villages was 9.0206%. The chi-square test for random effects showed that there was an extremely significant difference in the rate of farm abandonment at the village level (P=0.000), i.e., the village level factors had an important influence on the rate of farm abandonment, and it was necessary to add some explanatory variables in the *Level-2* model. Using the intragroup correlation coefficient (*ICC*) formula,

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the intragroup correlation coefficient of the model can be calculated as 101.9664/(101.9664+521.0150)=0.1637. Generally speaking, this value is greater than 0.059, which belongs to the medium degree of intragroup correlation, and it can be applied to the HLM analysis [86,87]. This value indicates that 16.37% of the variance in farm abandonment rate is village variance and the remaining 83.63% is farm household variance. This shows that although farm household differences are the main cause of differences in abandonment rates, the effect of village differences on them should not be underestimated.

Table 4. Null model estimation results.

Fixed Effects and Significance test				**Random effects and significance test**				
Parameters	**Regression coefficient**	**T-test**	**P-value**	**Parameters**	**Standard Deviation**	**Variance component**	**Chi-square test**	**P-value**
γ_{00}	9.0206	19.8610	0.000	μ_0	10.0978	101.9664	3164.5207	0.000
				r	22.8258	521.0150		

4.3. Random Effects Regression Model

The random effects regression model, which included only *Level-1* variables and did not include village-level variables in the equation, was used to determine the effect of *Level-1* variables on the explanatory variables and to determine whether the intercept and regression coefficients of *Level-1* variables had significant variation at the village level. In order to improve the accuracy of the full model, this study first used a one-factor random effects regression model to investigate the influence of individual explanatory variables of *Level-1* on the abandonment rate [87]; after that, we screened the factors with significant influence in the one-factor model and constructed a multifactor random effects regression model.

4.3.1. One-factor Random Effects Regression Model

Taking the abandonment rate as the explained variable, *Level-1* variables were introduced one by one in a non-centralized way to construct a one-factor random effects regression model, and no variables were introduced in the *Level-2* model. The effect of farmer-level variables on abandonment rate was tested by the fixed effects statistics of the model. The specific form of the model is shown below:

***Level*-1 model:**

$$QGZB_{ij} = \beta_{0j} + \beta_{1j}\left[EDU_{ij}/HEAL_{ij}/JTRKGM_{ij}/RJGDMJ_{ij}/ZRGDB_{ij}/TRWR_{ij}/SCGJ_{ij} /NYZL_{ij}/LNRJSR_{ij}/NYSRB_{ij}/FNSRB_{ij}/CGB_{ij}/LNRQZC_{ij}/HLWQK_{ij}\right] + \gamma_{ij} \quad (3)$$

***Level*-2 model:**

$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$
$$\beta_{1j} = \gamma_{10} + \mu_{1j}$$

In Equation (3), EDU_{ij} is the education level of the head of the household of the i_{th} farm household in the j_{th} village, and the rest of the Level-1 explanatory variables have similar meanings and represent the livelihood capital situation of each farm household in each village; the other variables have the same meanings as in equation (1).

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Table 5. Fixed effects estimates of one-factor random effects regression models.

Variable Name	Regression coefficient	standard error	T-test	P-value
EDU	-0.5046	0.6864	-0.735	0.462
HEAL	-1.6655	0.4355	-3.824	0.000***
JTRKGM	-0.0124	0.1004	-0.124	0.902
RJGDMJ	-0.5925	0.0523	-11.341	0.000***
ZRGDB	-0.0617	0.0086	-7.213	0.000***
TRWR	-0.4463	0.5051	-0.884	0.378
SCGJ	-4.3581	0.5950	-7.325	0.000***
NYZL	-0.6327	0.4236	-1.494	0.136
LNRJSR	-0.3407	0.2185	-1.559	0.119
NYSRB	-0.0872	0.0061	-14.313	0.000***
FNSRB	0.0431	0.0061	7.078	0.000***
CGB	-2.7299	1.2966	-2.105	0.035**
LNRQZC	-0.0250	0.0641	-0.390	0.697
HLWQK	-0.2000	0.4305	-0.465	0.642

Note: P < 0.01, extremely significant, labeled ***; P<0.05, significant, labeled **; P<0.1, generally significant, labeled *.

The fixed effects estimation results of the one-factor random effects regression model show that the human capital, natural capital, physical capital, financial capital and social capital of farmers have different degrees of influence on the abandonment rate.

(1) Among human capital, whether the head of household is relatively healthy has an extremely significant negative effect on the abandonment rate of farm households, which is consistent with the expected direction of the effect, indicating that the healthier the head of household is, the lower the abandonment rate of farm households. This may be because the head of household plays a major role in determining the direction and content of household production and management activities, and the healthier the head of household is, the more energy and stamina he or she will have to engage in a variety of production activities, including agricultural production, and the farmland will not be easily abandoned [88,89]. (2) In natural capital, the per capita cropland area and the ratio of transferred cropland have extremely significant negative impacts on the abandonment rate of farm households, which is consistent with the expected direction of action, indicating that the larger the per capita cropland area and the higher the ratio of transferred cropland, the lower the abandonment rate of farm households. This may be because the number of cropland is an important guarantee of cropland yield, the larger the per capita cropland area, the better the cropland resource endowment of the farmers, the more convenient the scale and mechanization of production and operation, the cropland yield and agricultural income are guaranteed, and the cropland is not easy to be abandoned [89,90]; the purpose of the farmers transferring to other people's cropland is the same in order to realize the scale of operation, and to seek a higher agricultural income, so when the total cropland area has a larger area of transferred cropland, in order to obtain agricultural income that is greater than the cost of land parcels, farmers tend to continue to engage in agricultural production [91]. (3) Among the physical capital, whether or not to own large agricultural production machinery or livestock used for agricultural production has an extremely significant negative effect on the abandonment rate of farm households, which is consistent with the expected direction of the effect, which indicates that the abandonment rate of farm households who own agricultural production machinery or livestock is lower. This may be because agricultural production equipment or livestock as a supporting facility for agricultural production, not only can make farmers operate a larger area of farmland, improve

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yields and increase agricultural income; and enough to reduce the input of agricultural labor, prompting farmers to have the opportunity to engage in a variety of production and management activities, the abandonment rate of farmland is not easy to be abandoned [92,93]. (4) In financial capital, the agricultural income ratio has an extremely significant negative effect on the abandonment rate of farm households, while the non-farm income ratio has an extremely significant positive effect on the abandonment rate of farm households, which is consistent with the expected direction of action, which indicates that the higher the agricultural income ratio, the lower the rate of abandonment of farm households [35,42]; the higher the non-farm income ratio, the higher the rate of abandonment of farm households, which may be due to the fact that the agricultural income ratio and the non-farm income ratio reflect the differences in the main sources of income of farm households, farm households relying on agricultural income may be less prone to abandonment of cropland, while farm households with predominantly non-farm income are more prone to abandonment of cropland [22,39]. (5) In social capital, the presence of village cadres has a significant negative effect on the abandonment rate of farm households, which is consistent with the expected direction of the effect. This may be because the village cadres in the farm household are more likely to understand the requirements of farmland protection policies, have a higher degree of awareness of the serious situation and importance of farmland protection, and need to play a good role as a model for farmland protection, so that the rate of abandonment of farmland is lower [89,94].

4.3.2. Multi-factor Random Effects Regression Model

Based on the statistical results of the one-factor model, a multi-factor random effects regression model is constructed. Taking the abandonment rate as the explained variable, the *Level-1* variables in the one-factor model, which have a significant effect on the abandonment rate, are added to the *Level-1* model in a non-centralized way, and no variables are added to the *Level-2* model. The specific form of the model is shown below:

***Level*-1 model:**

$$QGZB_{ij} = \beta_{0j} + \beta_{1j}HEAL_{ij} + \beta_{2j}RJGDMJ_{ij} + \beta_{3j}ZRGDB_{ij} + \beta_{4j}SCGJ_{ij} + \beta_{5j}NYSRB_{ij} + \beta_{6j}FNSRB_{ij} + \beta_{7j}CGB_{ij} + \gamma_{ij} \quad (4)$$

***Level*-2 model:**

$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$
$$\beta_{1j} = \gamma_{10} + \mu_{1j}$$
$$\beta_{2j} = \gamma_{20} + \mu_{2j}$$
$$\beta_{3j} = \gamma_{30} + \mu_{3j}$$
$$\beta_{4j} = \gamma_{40} + \mu_{4j}$$
$$\beta_{5j} = \gamma_{50} + \mu_{5j}$$
$$\beta_{6j} = \gamma_{60} + \mu_{6j}$$
$$\beta_{7j} = \gamma_{70} + \mu_{7j}$$

In Equation (4), the variables have the same meaning as in equations (1) and (3).

Comparing the fixed effects estimation results of one-factor and multi-factor random effects regression models, it can be found that the overall impact trend of the regression coefficients of most of the indicators remains the same, and there are only different degrees of weak changes in the coefficient size, which may be due to the existence of multiple covariates among multiple variables in the multi-factor model [87]; among them, the impact of the non-farm income ratio on the abandonment of farmland rate is changed from a significant positive impact to a non-significant impact, and the probable reason is that the multicollinearity of this indicator is relatively large, which affects the regression results [87], in view of this, this study considered to exclude the non-farm income

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ratio in the full model in order to improve the reliability of the model regression results. Meanwhile, the fixed-effects estimation results show that the overall average of the abandonment rate of all villages is 13.2053%; the abandonment rate will decrease by 1.9220% if the head of the household is healthier; the abandonment rate will decrease by 0.1843% for every increase in per capita cropland area; the abandonment rate will decrease by 0.0374% for every increase in the ratio of transferred cropland by 1%; and for every increase in the ratio of transferred cropland by 1%; and for every increase in the ratio of households owning large agricultural production for agricultural The abandonment rate decreases by 2.3390% for households owning large agricultural machinery or livestock used for agricultural production; the abandonment rate decreases by 0.0792% for every 1% increase in the ratio of agricultural income; and the abandonment rate decreases by 3.8157% for households owning village cadres.

The results of the random effects estimates are used to characterize whether there is significant two-level variation in the regression coefficients of the intercept term and *Level-1* variables. As can be seen from Table 6, (1) the chi-square test result of the intercept term is significant, with a p-value of 0.000, indicating that there are significant village differences in the mean value of farm abandonment rate among villages, and it is necessary to add the village-level variables in the subsequent analysis for the analysis of background effects; (2) the chi-square test results of the regression coefficients of the ratio of the transferred to cropland, the possession of large-scale agricultural production machinery or livestock used for agricultural production, and the ratio of the farm income on the abandonment rate of the farmers are significant, with p-values of 0.085, 0.040 and 0.000 respectively, that is, among different villages, there are significant inter-group differences in the negative impacts of the ratio of transferred cropland, the possession of large-scale agricultural production machinery or livestock used for agricultural production, and the ratio of agricultural income on the rate of abandonment of farming by farm households, and it is necessary to add village-level explanatory variables in the full model, to clarify the moderating effect of their effects on the impacts of household-level variables on the rate of abandonment; (3) the negative effects of other variables are relatively consistent across villages.

Table 6. Estimates of multifactor random effects regression models.

Variable Name	Fixed effects regression results			Random effects regression results	
	Regression coefficient	standard error	T-test	Variance component	Chi-square test
γ_{00}	13.2053	0.8196	16.112***	222.4776	141.8825***
HEAL	-1.9220	0.4144	-4.638***	3.3173	45.7651
RJGDMJ	-0.1843	0.0460	-4.006***	0.0344	47.4904
ZRGDB	-0.0374	0.0087	-4.300***	0.0022	55.0921*
SCGJ	-2.3390	0.5426	-4.310***	21.1288	59.3682**
NYSRB	-0.0792	0.0075	-10.522***	0.0124	84.2431***
FNSRB	0.0003	0.0078	0.036	0.0108	57.9672*
CGB	-3.8157	1.2928	-2.951***	22.7815	38.7926

Note: P < 0.01, extremely significant, labeled ***; P<0.05, significant, labeled **; P<0.1, generally significant, labeled *.

Comparing the *Level-1* random effects estimation results of the multifactor random effects regression model and the null model [85], this study calculated the overall explanatory power of the *Level-1* explanatory variables on the explained variables, and obtained that the variance shrinkage ratio of the *Level-1* random term was (521.0150-484.4892)/ 521.0150=0.0701, which indicated that the head of household being relatively healthy, per capita area of cropland, ratio of transferred cropland,

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ownership of large agricultural production machinery or livestock for agricultural production, ratio of agricultural income, ratio of non-farm income, and presence of village cadres can explain 7.01% of the within-group variance in the rate of abandonment of farming by farm households.

4.4. Intercept Model

The intercept term in the *Level-1* model was used as an explained variable, and the *Level-2* variables were added to the *Level-2* model in a non-centered manner to construct an intercept model in order to test whether the village level variables have a significant effect on the abandonment rate. The specific form of the model is shown below:

***Level*-1 model:**

$$QGZB_{ij} = \beta_{0j} + \gamma_{ij} \quad (5)$$

***Level*-2 model:**

$$\beta_{0j} = \gamma_{00} + \gamma_{01}TQJL_j + \gamma_{02}DLWZ_j + \gamma_{03}CZDX_j + \gamma_{04}CZNYSCB_j + \gamma_{05}FNQY_j + \gamma_{06}HNFW_j + \gamma_{07}TDZY_j + \mu_{0j}$$

In Equation (5), $TQJL_j$ is the commuting distance to the j_{th} village, and the rest of the *Level-2* explanatory variables have similar meanings, which represent the physical geography and socio-economic situation of each village; the meanings of all other variables are the same as in equation (1).

The fixed effects estimation results show that the abandonment rates are all affected to varying degrees by the physical geographic and socio-economic characteristics of the villages.

Table 7 shows that the regression coefficients of five variables, namely, commuting distance, whether it is a suburb of a large or medium-sized city, whether the topography of the village is a plain or not, the ratio of the number of people in agricultural production in the village, and whether it has experienced land expropriation, passed the significance test for the intercept term β_0. Among them, commuting distance, whether the terrain of the village is plain or not, and the ratio of the number of agricultural producers in the village have extremely significant negative effects on the abandonment rate of farm households, which is consistent with the expected direction of effect; whether it is a suburb of a large or medium-sized city has a generally significant negative effect on the abandonment rate of farm households, which is opposite to the expected direction of effect; and whether it is experiencing land expropriation has a significant positive effect on the abandonment rate of farm households, which is consistent with the expected direction of effect. direction. An increase in commuting distance reduces the abandonment rate, probably because in villages with a long commuting distance, the farmers in the village have a heavier "land-loving plot", and the convenience of engaging in non-agricultural employment is relatively lower, which makes them more inclined to engage in agricultural production activities [95,96]. The flatter the topography of the village, the lower the rate of abandonment of farming, which may be due to the flat topography, more conducive to the scale of cultivated land and mechanized management, to improve agricultural income, and to maintain the incentive of agricultural production of farmers [21,25]. The higher the ratio of the number of people engaged in agricultural production in the village, the lower the abandonment rate, which may be due to the fact that farmers are prone to herd behavior and continue to operate cropland in such a production environment; at the same time, a large number of farmers engaged in agricultural production in the village also provides a relatively broad market for the transfer of agricultural land, which also reduces the abandonment rate of cropland [32,97]. The fact that villages are on the outskirts of large and medium-sized cities reduces the rate of cropland abandonment may be due to the fact that proximity to large and medium-sized cities, on the one hand, provides a relatively broad market for farmers' agricultural production activities and facilitates the sale of agricultural products; on the other hand, the convenient location provides the possibility for farmers to operate both agricultural and non-agricultural production activities at the same time. In villages that have experienced land expropriation, the abandonment rate will increase, probably because land expropriation will lead to the fragmentation of some farmers' farmland, resulting in the reduction of the area of farmland available for production and operation, which is not conducive to the realization

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of large-scale management and the transfer and trusteeship of farmland, reducing the incentive of farmers' agricultural production [21,32], and contributing to the increase in the rate of abandonment of farmland.

Table 7. Intercept model fixed effects estimation results.

Variable Name	Regression coefficient	Standard error	T-test
γ_{00}	15.3173	1.7085	8.965***
TQJL	-0.2571	0.0682	-3.771***
DLWZ	-2.5563	1.3533	-1.889*
CZDX	-4.7083	0.8881	-5.302***
CZNYSCB	-0.0586	0.0147	-3.993***
FNQY	0.0227	1.0449	0.022
HNFW	0.2797	1.3159	0.213
TDZY	1.9319	0.9553	2.022**

Note: P < 0.01, extremely significant, labeled ***; P<0.05, significant, labeled **; P<0.1, generally significant, labeled *.

Comparing the *Level-2* random effect estimates of the intercept model and the null model [85], the variance shrinkage ratio of the *Level-2* random term was calculated to be 0.0956, indicating that the village-level variables could explain 9.56% of the between-group variation in abandonment rate. The within-group conditional correlation coefficient was further calculated to be 15.04%, indicating that the proportion of inter-village variance to the total variance was reduced with the inclusion of the five village variables mentioned above.

4.5. Full Model

The full model was constructed based on the results of the multifactor random effects regression model and intercept model analysis. Variables with significant effects on abandonment rate at the farm household level were included in the *Level-1* model, in which continuous variables for moderating effect test were added with group mean centering. Variables with significant effects of village level on abandonment rate were included in *Level-2* model with intercept as explained variable; at the same time, these significant variables were included in *Level-2* model with slope of farm level variables with significant group differences as explained variable, where continuous type variables for the test of moderating effect were added by centering the total mean to verify the effect of village level factors on the effect of farm level factors on the moderating effect of the effect of abandonment rate. The specific form of the model is shown below:

***Level*-1 model:**

$$QGZB_{ij} = \beta_{0j} + \beta_{1j}HEAL_{ij} + \beta_{2j}RJGDMJ_{ij} + \beta_{3j}\left(ZRGDB_{ij} - \overline{ZRGDB}_{.j}\right) + \beta_{4j}SCGJ_{ij} + \beta_{5j}\left(NYSRB_{ij} - \overline{NYSRB}_{.j}\right) + \beta_{6j}CGB_{ij} + \gamma_{ij} \quad (6)$$

***Level*-2 model:**

$$\beta_{0j} = \gamma_{00} + \gamma_{01}TQJL_j + \gamma_{02}DLWZ_j + \gamma_{03}CZDX_j + \gamma_{04}CZNYSCB_j + \gamma_{05}TDZY_j + \mu_{0j}$$

$$\beta_{1j} = \gamma_{10} + \mu_{1j}$$

$$\beta_{2j} = \gamma_{20} + \mu_{2j}$$

$$\beta_{3j} = \gamma_{30} + \gamma_{31}\left(TQJL_j - \overline{TQJL}_{.}\right) + \gamma_{32}DLWZ_j + \gamma_{33}CZDX_j + \gamma_{34}\left(CZNYSCB_j - \overline{CZNYSCB}_{.}\right) + \gamma_{35}TDZY_j + \mu_{3j}$$

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$$\beta_{4j} = \gamma_{40} + \gamma_{41}\left(TQJL_j - \overline{TQJL_.}\right) + \gamma_{42}DLWZ_j + \gamma_{43}CZDX_j + \gamma_{44}\left(CZNYSCB_j - \overline{CZNYSCB_.}\right) + \gamma_{45}TDZY_j + \mu_{4j}$$

$$\beta_{5j} = \gamma_{50} + \gamma_{51}\left(TQJL_j - \overline{TQJL_.}\right) + \gamma_{52}DLWZ_j + \gamma_{53}CZDX_j + \gamma_{54}\left(CZNYSCB_j - \overline{CZNYSCB_.}\right) + \gamma_{55}TDZY_j + \mu_{5j}$$

$$\beta_{6j} = \gamma_{60} + \mu_{6j}$$

In Equation (6), the variables have the same meaning as in Equations (1), (4) and (5).

As can be seen from Table 8, the effects of significant variables at the farm household level and village level on the abandonment rate are similar to those estimated by the multifactor random effects regression model as well as the intercept model. In terms of village-level variables, commuting distance, whether the village terrain is plain or not, and the ratio of the number of people in agricultural production in the village still have extremely significant negative effects on the abandonment rate of farm households, whether it is a suburb of a large or medium-sized city still has a generally significant negative effect on the abandonment rate of farm households, while whether one has experienced land expropriation or not has a significant positive effect on the abandonment rate of farm households, with only slight differences in the size of the regression coefficients, which may be due to the introduction of village-level significant variables in the full model. The possible reason for this is that there is a certain moderating effect of the village-level variables introduced by the full model [87]. Based on the estimation results of the full model, this study focuses on analyzing the moderating effect of village-level variables on the effect of farm household-level variables on abandonment rate. When the regression coefficients of the village-level variables have the same sign as the regression coefficients of the farm household-level variables, it means that the village-level variables strengthen the influence of the farm household-level variables on the abandonment rate; when the regression coefficients of the village-level variables have the opposite sign of the regression coefficients of the farm household-level variables, it means that the village-level variables weaken the influence of the farm household-level variables on the abandonment rate [86].

Table 8. Full model fixed effects estimation results.

	Variable Name	Regression coefficient	Standard error	T-test	P-value
β_0	*Intercept term* γ_{00}	12.0579	0.7842	15.377	0.000
	TQJL γ_{01}	-0.2528	0.0677	-3.735	0.000
	DLWZ γ_{02}	-2.4540	1.3157	-1.865	0.062
	CZDX γ_{03}	-4.7223	0.8827	-5.350	0.000
	CZNYSCB γ_{04}	-0.0548	0.0148	-3.690	0.000
	TDZY γ_{05}	1.8234	0.9293	1.962	0.050
β_1	*HEAL* γ_{10}	-1.9073	0.4164	-4.581	0.000
β_2	*RJGDMJ* γ_{20}	-0.1975	0.0503	-3.927	0.000
β_3	*ZRGDB* γ_{30}	-0.0541	0.0125	-4.338	0.000
	*ZRGDB*TQJL* γ_{31}	0.0028	0.0015	1.820	0.069
	*ZRGDB*DLWZ* γ_{32}	-0.0387	0.0290	-1.337	0.182
	*ZRGDB*CZDX* γ_{33}	0.0058	0.0164	0.354	0.723
	*ZRGDB*CZNYSCB* γ_{34}	0.0007	0.0003	2.440	0.015
	*ZRGDB*TDZY* γ_{35}	0.0111	0.0188	0.592	0.554
β_4	*SCGJ* γ_{40}	-3.5314	0.8546	-4.132	0.000
	*SCGJ*TQJL* γ_{41}	0.0038	0.0879	0.044	0.966

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	*SCGJ*DLWZ* γ_{42}	-2.3175	1.3835	-1.675	0.094
	*SCGJ*CZDX* γ_{43}	3.0912	1.2162	2.542	0.012
	*SCGJ*CZNYSCB* γ_{44}	0.0071	0.0201	0.352	0.725
	*SCGJ*TDZY* γ_{45}	-1.1113	1.2374	-0.898	0.370
	NYSRB γ_{50}	-0.0685	0.0097	-7.093	0.000
	*NYSRB*TQJL* γ_{51}	0.0020	0.0011	1.849	0.064
	*NYSRB*DLWZ* γ_{52}	0.0026	0.0224	0.116	0.908
β_5	*NYSRB*CZDX* γ_{53}	0.0251	0.0120	2.092	0.037
	*NYSRB*CZNYSCB* γ_{54}	-0.0000	0.0002	-0.018	0.985
	*NYSRB*TDZY* γ_{55}	-0.0364	0.0127	-2.862	0.005
β_6	*CGB* γ_{60}	-3.6382	1.2818	-2.838	0.005

The significant moderating effects of the estimation results are as follows: (1) the slope of the commuting distance and the ratio of transferred farmland is generally significantly positively correlated with a regression coefficient of 0.0028, and the ratio of transferred farmland is extremely significantly negatively correlated with the abandonment rate, so the further the commuting distance is from the village, the weaker the negative correlation relationship will be between the ratio of transferred farmland and the abandonment rate. The slope of the ratio of the number of people in agricultural production in villages and the ratio of transferred farmland is generally significantly positively correlated, with a regression coefficient of 0.0007, whereas the ratio of transferred farmland is extremely significantly negatively correlated with the rate of abandoning farmland, therefore, the higher the ratio of the number of people in agricultural production in villages is, the weaker the negative correlation between the ratio of transferred farmland and the rate of abandoning farmland is. (2) The slope of the relationship of whether the village is a suburb of a large or medium-sized city and the ownership of large agricultural production machinery or livestock for agricultural production is generally significantly negatively correlated, with a regression coefficient of -2.3175, thus, the villages in the suburbs of a large or medium-sized city are extremely significantly negatively correlated with the rate of abandonment of cropland. The negative correlation between the availability of large agricultural production equipment or livestock and the abandonment rate is stronger in villages that are suburbs of large and medium-sized cities. There is a significant positive correlation between the topography of the village and the slope of the ownership of large agricultural production machinery or livestock for agricultural production, with a regression coefficient of 3.0912, whereas there is a highly significant negative correlation with the abandonment rate of the village, therefore, if the topography of the village is plain, the negative correlation between the slope of the ownership of large agricultural production machinery or livestock for agricultural production and the abandonment rate of the village is weaker. The weaker is the negative correlation between the ownership of large agricultural production machinery or livestock and the abandonment rate. (3) The slope of commuting distance and agricultural income ratio is generally significantly positively correlated, with a regression coefficient of 0.0020, and the agricultural income ratio is extremely significantly negatively correlated with the abandonment rate, so the further the commuting distance, the weaker the negative correlation of agricultural income ratio and abandonment rate. The slope of the agricultural income ratio is significantly positively correlated with village topography, with a regression coefficient of 0.0251, and a highly significant negative correlation with abandonment rate, so the weaker the negative correlation between the agricultural income ratio and abandonment rate, the more the village topography is plain. There is a highly significant negative correlation with the slope of the agricultural income ratio, with a regression coefficient of -0.0364, and a highly significant negative correlation with the abandonment rate, so that the villages that have experienced land

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acquisition have a stronger negative correlation between the agricultural income ratio and the abandonment rate.

From Table 9, it can be seen that after the introduction of the five *Level-2* variables of commuting distance, whether it is a suburb of a large or medium-sized city, whether the village is a plain, the ratio of the number of people in agricultural production in the village, and whether it has experienced land expropriation, the random effects of the ratio of the cropland that was transferred to cropland, the ratio of the number of people in agricultural production that owns a large-scale agricultural production machine or livestock used for agricultural production and the ratio of the agricultural income are still significant, which indicates that the introduction of *Level-2* variables to the *Level-1* variables needs to be enhanced, and further village-level related variables or higher-level variables need to be added for analysis [85]. Meanwhile, after further comparing the random effect estimation results of the full model random effect regression results and the multifactor random effect regression model, and calculating the variance reduction ratio, it was found that: (222.4776-130.3265)/222.4776=0.4142, that is to say, 41.42% of the difference in the mean value of abandonment of farmland rate in villages could be explained by the above five *Level-2* variables.

Table 9. Full model random effects regression results.

Variable Name	Random effects regression results	
	Variance component	Chi-square test
γ_{00}	130.3265	116.5629***
HEAL	2.7051	49.5024
RJGDMJ	0.0773	43.2623
ZRGDB	0.0027	52.8242*
SCGJ	35.0686	59.8170**
LNRJSR	8.7962	98.1779
NYSRB	0.0080	86.9579***
CGB	19.6672	34.9425

5. Conclusion and Discussion

5.1. Conclusion

(1) 83.63% of the differences in the abandonment rate of farm households are caused by the differences in farm households, and the farm household level factor is the main cause; 16.37% is caused by the differences in their villages, and the village level factor should not be underestimated. In terms of background effects, village-level factors not only have a direct effect on the average level of abandonment rate in each village, but also have a moderating effect on the effect of farm-household level factors on abandonment rate.

(2) The fixed-effects estimates of the single-factor and multifactor random-effects regression models show that the differences in farm abandonment rates are affected by all of the human, natural, physical, financial, and social capitals of farm households; based on the fixed-effects estimates of the multifactor random-effects regression model, whether the head of the household is healthier, the per capita area of cropland, the ratio of transferred cropland, the possession of large-scale agricultural production machinery for agricultural production or livestock, agricultural income ratio, and whether or not they have village cadres all have a significant negative effect on the abandonment rate. Meanwhile, the random effect estimation results of the multifactor random effect regression model show that there are significant village differences in the mean value of abandonment rate of farm households in each village, and there are also significant between-group differences in the negative impacts of the ratio of transferred cropland, the possession of large-scale agricultural

production machinery or livestock used in agricultural production, and the ratio of agricultural income on the abandonment rate.

(3) The fixed effects estimation results of the intercept model showed that commuting distance, whether it is a suburb of a large or medium-sized city, the topography of the village is plain or not, and the ratio of the number of people in agricultural production in the village have significant negative effects on the abandonment rate, while the experience of land expropriation or not has a significant positive effect on the abandonment rate.

(4) The results of the full model show that the farm household level variables with significant fixed effects in the multifactor random effects regression model as well as the village level variables with significant fixed effects in the intercept model can still pass the significance test and the direction of the effect remains the same. In terms of moderating effects, the slopes of commuting distance and the ratio of the number of people in agricultural production in villages are significantly positively correlated with the ratio of transferred cropland, weakening the negative correlation between the ratio of transferred cropland and the rate of abandonment of cropland. The slope of whether the village is a suburb of a large or medium-sized city is significantly negatively correlated with the ownership of large agricultural production implements or livestock, which strengthens the negative correlation between the ownership of large agricultural production implements or livestock and the abandonment rate; whereas the slope of whether the village is a plain is significantly positively correlated with the ownership of large agricultural production implements or livestock and weakens the negative correlation between the ownership of large agricultural production implements or livestock and the abandonment rate. Commuting distance and whether the village is a plain are significantly positively associated with the slope of the agricultural income ratio, weakening the negative association between the agricultural income ratio and abandonment; and whether the village has experienced land confiscation is significantly negatively associated with the agricultural income ratio, strengthening the negative association between the agricultural income ratio and abandonment.

(5) By calculating the variance reduction ratios of the random effects regression model, the intercept model and the complete model, it can be found that the factors at the household level can to some extent effectively explain the intra-group differences in the differences in the levels of cropland abandonment; and the factors at the village level can to some extent effectively explain the inter-group differences in the levels of cropland abandonment and the differences in the mean values of abandonment rates of the villages.

5.2. Discussion

Due to the limitation of time and effort, the data used in this study are second-hand data, which makes the selection of variables and the determination of the explanatory level subject to certain limitations, resulting in the following two deficiencies in the results of the data analysis: (1) most of the variance reduction ratios computed are relatively small; (2) the slope of the influence of the farmer-level variables on the abandonment rate is still significant after adding the village-level variables to analyze the background effect. In view of this, we can optimize and adjust the variables at each level and add higher-level variables affecting the abandonment rate by changing the second-hand data to first-hand research data in the future, with a view to continuously improving the explanatory ability of the selected explanatory variables on the abandonment rate, and making the inter-group differences in the impact of the explanatory variables on the abandonment rate at the farmer household level more scientifically explained.

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