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A Study on the Impact of Natural Disasters on Farmers' Relative Poverty

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In 2020, China announced the successful completion of its poverty alleviation mission, noting that the focus of China's poverty alleviation mission has shifted from eliminating absolute poverty to alleviating relative poverty. Due to global warming and frequent natural disasters, natural disaster shocks have seriously affected farmers' livelihoods and aggravated relative poverty. Based on 5,804 rural household samples from the China Family Panel Studies, the impact of natural disasters on farmers' relative poverty was investigated using the logit model. In addition, the interaction terms between the impact and intensity of natural disasters, non-agricultural employment and productive investment were included in the model. The results show that: 1) Natural disaster shocks and natural disaster intensities had a significant positive impact on farmers' relative poverty. 2) Migrating for work and stable employment effectively alleviated the positive impact of natural disaster shocks and natural disaster intensities on farmers' relative poverty, respectively. 3) Productive investment weakened the positive impact of natural disaster shocks on farmers' relative poverty. 4) Scale management effectively alleviated the positive impact of natural disaster shocks on farmers' relative poverty, but the moderating effect of scale management was not significant in areas with high disaster intensities.

Keywords: natural disaster shock, relative poverty, productive investment, non-agricultural income, moderating effect

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1 INTRODUCTION

Countries around the world have suffered from huge economic losses due to the occurrence of natural disasters. According to the data from the Centre for Research on the Epidemiology of Disasters, global economic losses caused by natural disasters reached 210.1 billion US dollars in 2017, 49% higher than the historical average (Mohamed et al., 2015; Below and Wallemacq, 2018). In particular, due to the frequent occurrence of extreme climate disasters caused by global warming, current agricultural production systems worldwide are under serious threat (IPCC, 2022). Climate warming caused by human activities has exerted significant negative impacts on global crop production, hindering the growth of agricultural production. From 1961 to 2017, anthropogenic global warming had an average negative impact of 5.3% on three main crops, with 5.9%, 4.9% and 4.2% for maize, wheat and rice, respectively (Moore, 2020). In addition, the impact of different types of natural disasters worldwide shows an annually increasing trend. Arid areas in the world have expanded in the past 60 years and will continue to expand in the 21st century. By the end of the 21st century, global arid areas are expected to increase by 10% compared to those in 1961–1990 (Feng and Fu, 2013); drought disasters cause about 50% of the losses from climate disasters (Zhang et al., 2016). With a large territory, China is more vulnerable to natural disasters. From 1990 to 2018, the number

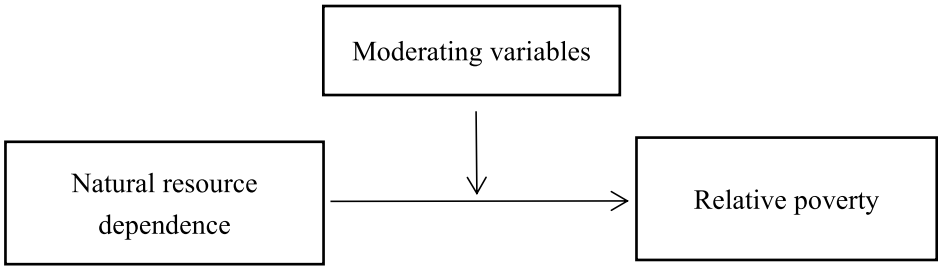

FIGURE 1 | Path analysis diagram of moderating variables.

of floods that occurred in the Asia-Pacific region gradually increased, and China was one of the countries most affected in the region (Kimuli et al., 2021). A total of 69% of China's land is located in mountainous and hilly areas, where 45% of the population lives. In addition to climate disasters, geological disasters have also caused enormous losses. With increasing frequent crustal activities, the impact of natural disasters such as earthquakes and landslides has substantially increased in the past few decades (Xu et al., 2017; Xu et al., 2020). People living in poverty are typically the most vulnerable to the devastating effects of earthquakes (Xu et al., 2019). In the past few decades, these natural disasters have had the most serious impact on impoverished people in underdeveloped areas. According to relevant forecasts, current trends in climate change may exacerbate these impacts in the future and thus lead to the unsustainable development of many regions (Mcbean and Rodgers, 2010).

As a developing country, China has attached great importance to poverty governance in recent years. In 2020, the Chinese government announced the successful completion of the poverty alleviation mission under the current poverty standard (Zeng at el., 2021). China's achievements in poverty alleviation do not mean that the task has come to an end. In contrast, it indicates that China's poverty alleviation mission has entered a brand-new stage of governing relative poverty rather than eliminating absolute poverty (Fan and Zou, 2021). A wide variety of studies have been carried out on poverty identification and poverty alleviation measures. However, the relationship between natural disasters and relative poverty has rarely been studied from the perspective of frequent natural disasters. China's achievements China in poverty alleviation in recent years can serve as an excellent sample for this research. Based on the impact of natural disasters, this paper studied the relationship between natural disasters and farmers' relative poverty as well as corresponding countermeasures. This not only further explains the causes of relative poverty in China, but also provides some ideas for formulating poverty alleviation policies.

2 LITERATURE REVIEW

Runciman and Walter (1974) applied the concept of relative deprivation to the study of poverty, arguing that people whose income levels can only enable them to live below the average living standard of society should also be categorized as the poor population. This laid a theoretical foundation for the concept of relative poverty. Poverty et al., 1971 proposed the concept of relative poverty, i.e., "poverty refers to not only the lack of necessities of life but also the shortage of resources of individuals, households and social organizations in many aspects, e.g., necessities of life, entertainment and social activities, which hinders households from reaching the average living standard encouraged and advocated by social customs or society".

Most studies on relative poverty focus on the identification and measurement of relative poverty (Zuhang et al., 2010) The poverty line and the multidimensional poverty identification method are commonly used to define poverty. The poverty line contains four measurement methods. The first measure is the budget standard line, which is used to measure relative poverty and absolute poverty. If the poverty line is based on the income level needed to afford to buy necessities such as food and clothes and to pay for accommodation, this line measures the absolute poverty; if the poverty line is set according to a socially acceptable living standard, this line measures the relative poverty line (Deeming, 2005). The second method is the social index method, which first calculates the deprivation degree of group members and then calculates the relative poverty line based on the relationship between income and deprivation degree (Shorrocks, 1980). The difficulty with this method lies in calculating the deprivation degree of group members. The deprivation is multifaceted, and, therefore, under normal circumstances, only items that are considered essential by most of the population can be used as deprivation indices. The third method is the extended linear expenditure (ELE) system method, which is a method to measure the relative poverty line based on the ELE system (Lluch, 1973). This method is similar to the budget standard method, with the only difference that the budget standard method requires representatives to figure out the types of necessities, whilst the ELE system method calculates the relative poverty line by distinguishing necessities from non-necessities according to residents' consumption data. The fourth method is the income method, which takes a certain proportion of the income concentration of society as the relative poverty line, e.g., the mean and median. Fuchs (1969) and Drewnowski (1977) proposed to set the relative poverty standard at 50% of median incomes and 50% of average incomes, respectively.

The premise of multidimensional relative poverty measurement is that poverty is not only characterized by low incomes, but also by low capabilities. Thus, it is necessary to identify the poor population in multiple dimensions or based on the weighted aggregate index. Duncan and Hagenaars (1987) constructed the H-M index by describing poverty from two dimensions, i.e., income and leisure. The advantage of this index is that it is relatively easier to obtain statistical data on income and leisure in actual measurement. The human poverty index (HPI) was first proposed by the United Nations Development Programme in its Human Development Reports published in 1997. This index is constructed in three dimensions, i.e., a long and healthy life, knowledgeable and decent standard of living, to guide people to reflect on poverty from a multi-dimensional perspective. To realize cross-regional comparison and dynamic tracking, Alkire and Foster (2011) put forward a multidimensional poverty measurement method based on Sen's capability theory (Srinivasan and Sen, 1983). Referred to as the A-F method, this method integrates the identification, aggregation and decomposition of poverty. This method not only reveals the root cause and essence of poverty, but also overcomes the shortcomings of other multidimensional methods in measuring and calculating poverty. It has become the main multidimensional relative poverty research tool that can accurately identify impoverished people. Since the A-F method was proposed, a large number of studies have been conducted using this method to establish measurement index systems and methods for different objects in different regions, groups and periods.

Poverty is generally considered as the main outcome of the impact of climate change on individuals and households. Climate change may directly or indirectly aggravate poverty and form poverty traps in many ways, especially in underdeveloped countries and regions (Leichenko and Silva, 2014). Most studies on the impact of climate disasters on poverty have focused on analyzing the impact of climate disasters on agricultural production and then explaining the variation of farmers' poverty based on fluctuations in agricultural incomes. It is commonly concluded that natural disasters reduce farmers' incomes. Carter et al., 2005 demonstrated that natural disasters are likely to trap households into long-term poverty by exploring the influences of drought and hurricanes on farmers' agricultural production in Ethiopia and Honduras. Bloom et al., 2003 verified that natural disasters affect farmers' incomes from the perspective of geographical differences. Mohamed et al. (2015) analyzed the impact of natural disasters on Vietnamese households, concluding that natural disasters are negatively correlated with household incomes and expenditures. They found that natural disasters such as storms, floods and droughts reduced household incomes by about 1.9%, 5.9% and 5.2%, respectively, and household expenditures by 1.5%, 4.4% and 3.5%, respectively. Guo et al., 2014 found that farmers strongly dependent on natural resources are very sensitive to natural disasters since natural disasters can cause serious losses of livelihood resources and adversely affect farmers' sustainable incomes. Mottaleb et al. (2013) found that farmers affected by natural disasters may increase their food expenditures while lowering their education expenditures, which hinders the long-term development of human capital. However, some studies have found that natural disasters can also positively influence farmers' incomes. According to the analysis by Banerjee (2007), the demand for agricultural labor in Bangladesh increased after the floods, and the income of rural laborers who depended on agricultural incomes for a living also increased. Some researchers have interpreted the relationship between natural disasters and poverty based on the impact of natural disasters on farmers' assets. Beltran et al., 2018 believed that areas with a high incidence of natural disasters may be more seriously struck by poverty because impoverished people prefer to settle in these areas, such as low-lying areas of cities with lower living costs. Ajibade and Mcbean, 2014 also found that poor communities are extremely vulnerable to floods and extreme climate change, associated with rapid urbanization, environmental degradation and low disaster relief level. The study of Bui et al., 2014 also proved this, stating that natural disasters directly damage farmers' assets. When the current asset level drops to a certain threshold, farmers will fall into the "poverty trap" and it is difficult for them to escape. According to Ferreira et al. (2011), in Mexico, floods affect the current and future livelihoods of households, and asset losses from natural disasters will further exacerbate local poverty. In exploring the influences of natural disasters on farmers' incomes and assets, some researchers have conducted selective analyses on the impact of natural disasters on poverty. Bayudan-Dacuycuy and Lim, 2013 studied the influencing factors of short- and long-term poverty in the Philippines. The study results show that natural disasters directly lead to or aggravate short-term poverty of households affected by natural disasters, while the unemployment and illnesses of family members due to natural disasters result in long-term household poverty. Thurlow et al. (2012) analyzed the influence of natural disasters on poverty in Zambia using a dynamic general equilibrium model and found that natural disasters will cost Zambia 430 million US dollars every 10 years and that reduced rainfall will intensify the poverty in Zambia. Rodriguez-Oreggia et al., 2013 suggested that the impact of general natural disasters will significantly lower the human development level and substantially aggravate poverty. By analyzing the drought in a region of Ethiopia, Little et al., 2006 found that droughts have a slight effect on the incidence of poverty.

3 RESEARCH HYPOTHESES

The above studies have explored the impact of natural disasters on farmers' poverty and incomes, which is significant for reference purposes. Natural disasters cause poverty mainly through disaster-causing factors, disaster-bearing bodies and disaster risks (Yang et al., 2010). Disaster-causing factors can lead to poverty when farmers fail to maintain their normal life because of economic damage and casualties under the impact of major natural disasters. The poverty caused by disaster-bearing bodies is manifested in the additional losses and potential impacts of farmers with different resource endowments when faced with disasters of the same intensity due to their poor livelihood

resilience and adaptability. This amplifies the poverty-causing effect of disasters (Zuhang et al., 2010). Disaster risk-induced poverty refers to hidden poverty driven by different disasters (Zhang and Zuhang, 2011). Intensive disasters with low frequency but high loss and extensive disasters with high frequency but low loss influence farmers' poverty in different ways. The former directly causes economic losses and casualties to farmers' households, while the latter has more cumulative indirect effects. For example, frequent rainstorms and droughts are the main causes of declining agricultural production and insecurity of farmers' livelihoods. Hypothesis one was proposed:

H1: Due to the shock and intensity of natural disasters, farmers will be caught in relative poverty.

Mediating mechanism of migrating for non-agricultural employment. Natural disasters often have an imperative impact on the decision making of individuals and households. Under the impact of various risks, farmers with fewer livelihood assets can choose more conservative livelihood adaptation strategies, such as migrating for work (Deng and Zhong, 2020). In addition, with a stronger buffer capacity in livelihood resilience, rural residents tend to engage more in non-agricultural activities to increase income (Zhou et al., 2021). There are two ways to alleviate the relative poverty of rural households by migrating for work. Firstly, farmers increase the proportion of non-agricultural income in household income by migrating for work, improving their income structure and thus effectively reducing the impact of natural disasters on farmers' income and the risk of farmers falling into relative poverty (Deng and Zhong, 2020). Secondly, migrating for work is conducive to optimizing the resource allocation of agricultural labor, improving farmers' labor quality through the "learning-by-doing" effect, increasing farmers' income level and reducing the risk of farmers falling into relative poverty (Han et al., 2017). Starting from the moderating effect of migrant workers, this paper explored the poverty alleviation effects of migrant workers and employment stability. Thus, Hypothesis two was proposed:

H2: Migrating for non-agricultural work and stable employment can relieve the impact of natural disasters on farmers' relative poverty.

Mediating mechanism of productive investment. Productive investment includes fixed investment and liquid investment. Fixed investment mainly includes the construction of irrigation and water conservancy, construction of agricultural production housing, purchase of machinery and equipment and other fixed assets required for agricultural production. Fixed investment not only helps farmers resist disaster risks and reduce economic losses, but also contributes to improving agricultural production efficiency, increasing farmers' incomes and eliminating relative poverty (Imai et al., 2010). Liquid investment, also known as traditional investment, mainly includes investment in agricultural production such as seeds, fertilizers and pesticides (Gao et al., 2017). Impacted by natural disasters, farmers pay more attention to the uncertainty of crop losses and gains, and their awareness of risk aversion also increases. According to the prospect theory (Heutel, 2019), farmers will increase their investment in the yield-increasing input factors and liquid investment for agricultural production. In addition, the rational allocation of chemical fertilizers and pesticides also contributes to increasing agricultural production, helps farmers increase their agricultural incomes and alleviates relative poverty. Thus, Hypothesis three was proposed:

H3: Productive investment can relieve the impact of natural disasters on farmers' relative poverty.

Mediating mechanism of scale management. Existing research shows that agricultural scale management helps farmers reduce production costs and improve the level of modernization. It can also improve the marginal productivity and production efficiency of agricultural labor. Based on the household survey data collected from Jiangsu Province in China, Lu et al., 2019a found that scale management can not only increase the marginal productivity of agricultural labor, but also increase the supply of agricultural labor force (Lu et al., 2019b). Manjunatha et al., 2013 found that land fragmentation has a significant positive correlation with inefficiency and has a significant negative effect on farm profit. Liu and Jin, 2016 analyzed the difference in the technical efficiency distribution of rice production and their impacting factors under different scales of management, and found that land subcontracting imposes positive effects on technical efficiency. Scale management can help farmers improve production efficiency and thus resist the impact of natural disasters. Thus, Hypothesis four was proposed:

H4: Scale management can weaken the impact of natural disasters on farmers' relative poverty.

4 MATERIALS AND METHODS

4.1 Data Sources

The data used in this paper was extracted from China Family Panel Studies (CFPS), which is a nationally representative large-scale household survey implemented by the Institute of Social Science Survey at Peking University. It aims to reflect social, economic, demographic, educational and health changes in China by tracking and collecting data from individuals, households and communities. The CFPS covers the microdata of households in most provinces, municipalities and autonomous regions in China. The 2014 CFPS database was selected for this paper, and the sample covered the population of 25 provinces (municipalities and autonomous regions) in China except for Hong Kong, Macau, Taiwan, Xinjiang, Tibet, Qinghai, Inner Mongolia, Ningxia and Hainan. In terms of the relative poverty of rural households, the CFPS database covers information on farmers' income and living standards as well as family members' health, education, employment and social security. By excluding some samples with serious missing data, 5,804 household samples in 2014 were finally obtained.

4.2 Variable Setting

Relative poverty is the explained variable. Relative poverty refers to a condition that indicates whether rural households fall into relative poverty. Currently available studies have shown that the

TABLE 1 | Descriptive statistics of control variables.

Variable	Definition	Mean	Variance
Relative poverty	Whether the households are caught in relative poverty (yes = 1; no = 0)	0.1671	0.3731
Natural disaster shock	Whether the regions where the rural households are located have been impacted by natural disasters in recent years	0.7715	0.4199
Natural disaster intensity	Type of natural disasters (value = 1–5)	1.9623	1.5673
Gender of the household head	Gender of the household head (male = 1; female = 0)	0.5701	0.4951
Age of the household head	Actual age of the household head/year	49.2367	12.9052
Square term of the age of the household head	Square term of the actual age of the household head	2,590.7720	1,278.0390
Years of schooling	Education background of the household head/year	6.2255	4.1623
Marital status of the household head	Marital status of the household head (married = 1; unmarried = 0)	0.8866	0.3171
Aspiration level	Confidence in the future (1 = unconfident; 2 = relatively unconfident; 3 = confident; 4 = relatively confident; 5 = very confident)	3.9712	1.0653
Proportion of agricultural income	Proportion of agricultural income in household income	0.2758	0.3416
Logarithm of total loan	Logarithm of household debt	1.9859	4.0281
Household burden coefficient	Proportion of non-labor force to total household population	0.3297	0.2716
Population size	Number of household members/person	4.1554	1.9051
Socialized services	Logarithm of the amount of money spent on renting agricultural machinery	2.2744	3.1524
Migrating for non-agricultural work	Proportion of migrant labor force in household labor force	0.3263	0.3626
Stable employment	Proportion of the migrant population who signed labor contracts in the migrant population	0.0612	0.2149
Fixed investment	Total value of agricultural machinery/yuan (logarithm)	6.0071	3.3330
Liquid investment	Total investment in seeds, fertilizers and pesticides/yuan (logarithm)	3.6238	3.8980
Logarithm of leased land	The logarithm of the payment for land transfer	0.8208	2.2892

threshold for relative poverty is usually set at a certain percentage of mean or median income. Since mean income is greatly influenced by super-high income, the median income is more reliable than the mean income, and relative poverty is measured by median income in most studies (Song et al., 2020; Zhang and Shen, 2020). In this paper, based on the data of rural household samples of the 2014 CFPS, the relative poverty line was calculated by taking 60%, 50% and 40% of mean and median income, respectively. The mean income of rural households per capita in 2014 was about 11,324 Chinese yuan and the median was 7,514 Chinese yuan. Therefore, 40%, 50% and 60% of the mean per capita income of rural household samples in 2014 were 4,529.6, 5,662 and 6,794.4 Chinese yuan, respectively; 40%, 50% and 60% of the median per capita income of rural household samples were 3,005.6, 3,757 and 4,508.4 Chinese yuan, respectively. According to the national standards for poverty alleviation in China in 2011 (i.e., 2,300 Chinese yuan), the poverty line was 2,800, 3,146 and 3,535 Chinese yuan in 2014, 2016 and 2018, respectively. By comparing the calculated poverty line according to constant price with the average and median, it is found that the constant price of the poverty line was closer to 40% of the median. According to the reference, the relative poverty line should be set at 40% of the median per capita income (Song et al., 2020). Therefore, in the following measurement of the relative poverty line, 40% of the median per capita income of the rural household samples should be taken as the critical line. If it is lower than the relative poverty line, it is assigned as 1, i.e., the household income level belongs to relative poverty; otherwise, it is assigned as 0.

The natural disaster shock is the core explanatory variable. Two variables were designed in this paper. 1) Natural disaster shock. According to the question in a questionnaire survey conducted by the CFPS, "Have you been affected by the following natural disasters from 1 January 2010 to 31 December 2013?", this paper reported nine types of natural disasters in detail, such as drought, flood and typhoon. If a village suffers from natural disasters, the value is one; otherwise, the value is 0. 2) Natural disaster intensity. Natural disaster intensity was constructed based on the number and type of natural disasters that affected this region. The value of this variable ranged from 1 to 5. If a village is impacted by more than five types of natural disasters, the value is set as "5".

Control variables: According to relevant literature, the characteristics of the household head and the household were selected as the control variables (Song et al., 2022). The characteristics of the household head include gender, age, square term of the age, marital status and aspiration level of the household head. The characteristics of households include the proportion of agricultural income, land transfer, loan amount, household burden coefficient, population size and socialized services. **Table 1** shows the descriptive statistics of these variables.

Moderating variables: Migrating for non-agricultural work, productive investment and scale management were selected as the moderating variables. The variable of migrating for non-agricultural work refers to the proportion of migrant labor force in the household labor force; "total value of agricultural machinery/yuan (logarithm)" is the proxy variable of fixed investment; "total investment in seeds, fertilizers and pesticides/yuan (logarithm)" is the proxy variable of liquid investment.

4.3 Model Selection

4.3.1 Benchmark Model

$$Y = \beta_0 + \beta_1 X + \beta_2 control + \varepsilon \quad (1)$$

TABLE 2 | Impact of natural disasters on farmers' relative poverty.

Parameter	(1)	(2)
Natural disaster shock	0.0308***	
	[0.0104]	
Natural disaster intensity		0.0107***
		[0.0031]
Gender	0.0069	0.0044
	[0.0097]	[0.0097]
Age	-0.0069***	-0.0068***
	[0.0026]	[0.0026]
Square term of age	0.0001***	0.0001***
	[0.0000]	[0.0000]
Years of schooling	-0.0121***	-0.0120***
	[0.0013]	[0.0013]
Marital status	-0.0284	-0.0285*
	[0.0173]	[0.0173]
Aspiration level	-0.0198***	-0.0196***
	[0.0049]	[0.0049]
Proportion of agricultural income	0.0003***	0.0003***
	[0.0001]	[0.0001]
Whether the land is transferred	-0.0632***	-0.0625***
	[0.0142]	[0.0142]
Logarithm of total loan	0.0017	0.0015
	[0.0012]	[0.0012]
Household burden coefficient	0.0824***	0.0811***
	[0.0214]	[0.0213]
Population size	0.0229***	0.0227***
	[0.0031]	[0.0031]
Socialized services	-0.0059***	-0.0055***
	[0.0015]	[0.0014]
Constant term	0.2800***	0.2785***
	[0.0593]	[0.0587]
N	5,804	5,804
R^2	0.0859	0.0867

where Y denotes farmers' relative poverty, X stands for the impact and intensity of natural disasters, *control* represents a series of control variables, β_0 and ε refer to the constant term and the random disturbance term, β_1 and β_2 are the coefficients to be determined.

4.3.2 Moderating Effect Model

According to the study by Wen et al. (2005), when both explanatory variables and moderating variables are continuous variables, hierarchical regression can be carried out to test the role played by moderating variables between explanatory variables and the explained variable. As shown in **Figure 1**, in this paper, non-agricultural employment, fixed investment and liquid investment were selected as moderating variables between relative poverty and the impact of natural disasters. Firstly, the influences of natural disasters and moderating variables on relative poverty were analyzed, so as to obtain the determination coefficient R_1^2. Secondly, the determination coefficient R_2^2 of the influences of natural disasters, moderating variables and their interaction on relative poverty was analyzed. If $R_1^2 < R_2^2$, the regulatory effect is significant. The specific model of the moderating variables is as follows:

$$Y = \beta_0 + \beta_1 X + \beta_2 S + \beta_3 control + \varepsilon \quad (2)$$

$$Y = \beta_0 + \beta_1 X + \beta_2 S + \beta_3 X*S + \beta_4 control + \varepsilon \quad (3)$$

where Y denotes whether farmers are caught in relative poverty, X represents the impact and intensity of natural disasters, S stands for the regulatory variables (non-agricultural employment, productive investment and scale management), *control* refers to the control variables about the characteristics of the household head and the characteristics of the household, β denotes the parameter to be estimated and ε is the random disturbance term.

5 EMPIRICAL RESULTS AND ANALYSIS

5.1 Benchmark Regression

Table 2 shows the regression analysis results of the impact of natural disasters on farmers' relative poverty. Models 1) and 2) show the influence of the impact and intensity of natural disasters on farmers' relative poverty. From Column 1), the impact of natural disasters had a positive influence on farmers' relative poverty, highly significant at the level of 1%. Column 2) shows the influence of the intensity of natural disasters on farmers' relative poverty. Based on the results, the intensity of natural disasters had a significantly positive effect on farmers' relative poverty, highly significant at the level of 1%. Thus, Hypothesis one was verified. The reason is that the impact of natural disasters directly affects the source of farmers' agricultural income, resulting in a widening gap between farmers' income and migrant workers and thus falling into relative poverty. In addition, sudden natural disasters may directly damage farmers' fixed assets and personal safety, resulting in farmers falling into poverty due to disasters.

According to the estimation results of the control variables, all variables had consistent effects on farmers' relative poverty. In terms of the characteristics of the household head, age, square term of the age, educational background and marital status of the household head significantly influenced farmers' relative poverty. The age of the household head negatively affected farmers' relative poverty, while the square term of age exerted a positive impact on farmers' relative poverty, indicating that the relationship between the age of householders and farmers' relative poverty showed an in U shape. With the increase of age, farmers have got stronger capabilities to get rid of relative poverty; however, when they reach a certain age, they are likely to fall into relative poverty. Years of schooling and aspiration level had negative effects on farmers' relative poverty, indicating that the improvement of education background and aspiration level assisted farmers in escaping from relative poverty. As for the characteristics of households, a higher proportion of agricultural income may induce a higher probability of farmers falling into poverty. The possible explanation is that with the promotion of China's industrialization and urbanization, people's wage income has become much higher than their agricultural income, and compared with those migrating for non-agricultural work, households with agricultural labor force are more likely to fall into relative poverty. Population size and family burden

TABLE 3 | Estimation results of instrumental variables.

Parameter	(1)	Stage 1	Stage 2
ND	0.0308***		0.1152***
	[0.0104]		[0.0260]
Instrumental variable		0.9732***	
		[0.0305]	
IV inadequate identification test:Kleibergen. LM statistical value (*p* value)		633.656 (0.0000)	
Weak instrumental variable test:Cragg-Donald Wald F value		1,152.036	
N	5,804	5,804	5,804

TABLE 4 | Robustness test results.

Parameter	(1)	(2)	(3)	(4)
	Per Capita Income	Per Capita Income	Relative Poverty	Relative Poverty
Natural disaster shock	-0.1797***		0.2503***	
	[0.0331]		[0.0950]	
Natural disaster intensity		-0.0320***		0.0735***
		[0.0097]		[0.0239]
Control variable	Yes	Yes	Yes	Yes
N	5,804	5,804	5,804	5,804
R^2	0.1835	0.1813	0.0991	0.0996

coefficient had a positive effect on farmers' relative poverty, indicating that a larger population size and non-labor population will cause a higher probability of farmers falling into relative poverty. Farmers' behavior in adopting socialized services had a negative impact on relative poverty. Socialized services help farmers integrate into modernized agriculture and promote farmers' production efficiency by reducing costs and increasing efficiency, thereby helping farmers get rid of relative poverty.

5.2 Endogeneity Analysis

The collected survey data was likely to be influenced by the bias and memories of respondents. There may be missing variables that affect farmers' livelihood resilience, resulting in endogenous problems. In this paper, based on the studies by Pajaron and Vasquez (2020), the incidence of natural in the other areas of the same province was selected as the instrumental variable of the impact of natural disasters estimated in Model IV. The results of the CFPS2014 questionnaire survey covered natural disasters occurring from 2010 to 2013, and the probability of natural disasters in different districts and counties of the same province was similar within a long period. Thus, these results can reflect the occurrence of natural disasters in this village. In addition, the incidence of natural disasters in other areas was not directly correlated with farmers' relative poverty in these areas, which is consistent with the exogenous conditions.

According to the 2SLS estimation results in **Table 3**, the test results of inadequate identification by Model IV show that the LM statistical value (*p* values) of the model significantly rejected the original hypothesis, indicating that the model did not have any problem in adequately identifying the instrumental variables. The Cragg-Donald Wald F statistical value was significantly larger than the critical value of the StockYogo weak instrumental variable, indicating that the model did not have any problem in identifying weak instrumental variables. The regression results in Stage 1 showed a positive relationship between the incidence of natural disasters in surrounding areas and that in this area. The regression coefficient in Stage 2 was 0.1176, 0.0901 higher than the benchmark regression coefficient, and it passed the 1% significance test. This indicates that the estimation coefficient may be underestimated if the endogeneity problem is ignored.

5.3 Robustness Test

Firstly, the explained variable was replaced. The logit method was used for regression. By replacing relative poverty with per capita income, the results of Models 1) and 2) in **Table 4** show that natural disaster shocks and intensity both had a significant negative impact on farmers' per capita income at the level of 1%. This indicates that the disaster shocks can reduce farmers' per capita income. Disasters can lead farmers to fall into relative poverty. Secondly, Logit was used in Models 3) and 4) to analyze the impact of disaster shocks and intensity on farmers' relative poverty, as shown in **Table 4**. The results indicate that the baseline regression of natural disaster shocks and intensity on farmers' relative poverty was consistent, which was still significant. Overall, in terms of replacing the model or the explained variables, natural disaster shocks and intensity significantly affected farmers' relative poverty, indicating that the above empirical analysis results were robust.

5.4 Risk Response Mechanism

Natural disasters have a significant impact on farmers' relative poverty. Under disaster shocks, farmers tend to choose non-agricultural employment or productive investment to resist risks.

TABLE 5 | Test results of the moderating effect of non-agricultural employment.

Parameter	(1)	(2)	(3)	(4)
Natural disaster shock	0.0290***		0.0272***	
	[0.0105]		[0.0105]	
Non-agricultural employment	-0.0678***	-0.0682***		
	[0.0132]	[0.0132]		
Natural disaster shock*	-0.0617**			
Non-agricultural employment	[0.0280]			
Natural disaster intensity		0.0108***		0.0099***
		[0.0031]		[0.0031]
Natural disaster intensity*		-0.0182**		
Non-agricultural employment		[0.0080]		
Stable employment			-0.0598***	-0.0593***
			[0.0182]	[0.0181]
Natural disaster shock*			-0.0582	
Stable employment			[0.0402]	
Natural disaster intensity*				-0.0214**
Stable employment				[0.0105]
Control variable	Yes	Yes	Yes	Yes
N	5,804	5,804	5,804	5,804
R^2	0.0951	0.0960	0.0916	0.0925

Whether these factors can facilitate farmers' response to disaster shocks remains to be explored. In addition, for some farmers implementing scale management, the impact of disaster shocks still needs further clarification. Thus, this paper incorporated the interaction terms of natural disaster shocks and intensity with non-agricultural employment, productive investment and scale management into the model, and explored the influencing mechanism of these factors.

(1) Non-agricultural employment.

In order to test the moderating effects of non-agricultural employment and the employment stability in natural disasters and relative poverty, this paper incorporated non-agricultural employment and employment stability variables into the estimation equation and observed the performance of the interaction term between natural disaster shocks and natural disaster intensity. The results are shown in **Table 5**. Models 1) and 2) incorporated the interaction term between non-agricultural employment and natural disaster shocks and the interaction term between non-agricultural employment and disaster intensity, respectively. The empirical results both were significantly negative at the 5% level, indicating that non-agricultural employment can effectively alleviate farmers' relative poverty. The reason is that the income growth from non-agricultural employment can effectively compensate for the economic losses caused by disasters, which can facilitate household consumption and stabilize living quality. Models 3) and 4) incorporated the interaction term between employment stability and natural disaster shocks and the interaction term betweenemployment stability and disaster intensity, respectively. The results show that the interaction term between stable employment and natural disaster shocks did not significantly affect farmers' relative poverty, while the impact of employment stability and disaster intensity on farmers' relative poverty was significantly negative at the 5% level. This indicates that stable employment played a role in areas with high disaster intensity and can reduce the possibility of farmers falling into relative poverty, which is consistent with Hypothesis 2. It may be attributed to the fact that employment stability can ensure a stable income for farmers to cope with disaster shocks and offer farmers more opportunities to improve their economic and social status, enhance social mobility, and cope with disasters with a higher credit level.

TABLE 6 | Test results of the moderating effect of productivity.

Parameter	(1)	(2)	(3)	(4)
Natural disaster shock	0.0300***		0.0283***	
	[0.0106]		[0.0107]	
Fixed investment	-0.0052***	-0.0054***		
	[0.0012]	[0.0012]		
Natural disaster shock*	-0.0047*			
Fixed investment	[0.0026]			
Natural disaster intensity		0.0114***		0.0106***
		[0.0032]		[0.0032]
Natural disaster intensity*		-0.0015*		
Fixed investment		[0.0008]		
Fertilizer investment log			-0.0048***	-0.0050***
			[0.0018]	[0.0018]
Natural disaster shock*			-0.0051**	
Liquid investment			[0.0026]	
Natural disaster intensity*				-0.0020**
Liquid investment				[0.0008]
N	5,804	5,804	5,804	5,804
R^2	0.0936	0.0945	0.0918	0.0929

(2) Productive investment.

In order to test the moderating effect of productive investment in natural disasters and relative poverty, this paper incorporated fixed investment and liquidity variables into the estimation equation to observe the performance of natural disaster and

TABLE 7 | Test results of the moderating effect of scale management.

Parameter	(1)	(2)
Natural disaster shock	0.0284***	
	[0.0104]	
Scale management	-0.0109***	-0.0111***
	[0.0019]	[0.0018]
Natural disaster shock*	-0.0098**	
Scale management	[0.0043]	
Natural disaster intensity		0.0104***
		[0.0031]
Natural disaster intensity*		-0.0016
Scale management		[0.0011]
N	5,804	5,804
R^2	0.0953	0.0957

their interaction term. The results are shown in **Table 6**. Model 1) presents the empirical results of the interaction term between natural disaster shocks and fixed investment, and Model 2) shows the results of the interaction term between fixed investment and natural disaster intensity. The effects of the interaction terms of the two models on relative poverty were both significantly negative at the 10% level, indicating that fixed investment can effectively alleviate the impact of natural disasters on farmers' relative poverty. Model 3) shows the empirical results of the interaction term between natural disaster shocks and liquid investment, and Model 4) presents the results of the interaction term between liquid investment and natural disaster intensity. The effects of the interaction terms of the two models on relative poverty were both significantly negative at the 5% level, indicating that liquid investment can effectively alleviate the impact of natural disasters on farmers' relative poverty. In summary, productive investment can effectively moderate the positive impact of natural disasters on farmers' relative poverty, which is consistent with Hypothesis 3. This indicates that productive investment can improve farmers' capability to resist risks and help them cope with climate change.

(3) Scale management.

In order to test the moderating effect of scale management in natural disasters and relative poverty, the paper incorporated the scale management into the estimation equation and explored the impact of the interaction term between natural disaster shocks and scale management as well as that between natural disaster intensity and scale management on farmers' relative poverty. The results are shown in **Table 7**. Based on Models (1) and (2), the impact of scale management on farmers' relative poverty was significantly negative at the 1% level, indicating that scale management can help farmers get rid of relative poverty. In Model (1), the impact of the interaction term between natural disaster shock and scale management on farmers' relative poverty was significantly negative at the 5% level, indicating that scale management can effectively moderate "poverty caused by disasters". The reasons are as follows: after scale management, large-scale machinery and socialized services can better serve agricultural production, thereby ensuring stable agricultural production and income under disaster shocks; the scale effect due to scale management can effectively reduce the cost of resisting disasters and enhance the resilience in agricultural production. In Model (2), the interaction term between natural disaster intensity and scale management did not have a significant impact on farmers' relative poverty, indicating that in areas with high disaster intensity, the moderating effect of scale management did not exert a significant impact. The reason is that the improved disaster resistance capabilities of some large-scale operations cannot effectively resist high-intensity disaster shocks, but instead cause greater losses in agricultural production.

6 CONCLUSION

Based on the CFPS data, this paper studied the impact of natural disaster shocks and natural disaster intensity on farmers' relative poverty, and further verified the moderating mechanism of migrating for work, fixed investment and scale management in farmers' relative poverty caused by disaster shocks.

6.1 The Conclusions Are as Follows

1) Natural disaster shocks and natural disaster intensity have a significant positive impact on farmers' relative poverty.
2) Migrating for work can effectively alleviate the positive impact of disaster shocks on farmers' relative poverty. Stable employment can effectively alleviate the positive impact of natural disaster intensity on farmers' relative poverty.
3) Productive investment can weaken the positive impact of natural disaster shocks on farmers' relative poverty.
4) Scale management can effectively alleviate the positive impact of natural disaster shocks on farmers' relative poverty, but the moderating effect of scale management is not significant in areas with high disaster intensity.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication. XJ drafted and wrote the first draft of the manuscript. All authors reviewed and revised the manuscript, agreed to be accountable for all aspects of the work, read, and approved the final manuscript.

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