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Climate Shocks and Farmers' Agricultural Productive Investment: Resisting Risk or Escaping Production?

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Climate shocks can increase uncertainty in agricultural production. Using data from the China Family Panel Studies (CFPS), this study examines the impact of climate shocks on farmers' productive investment and its mechanism of village public productive investment. The study found the following: (1) The impact of climate shocks have a significant impact on farmers' productive investment choices. Farmers who are greatly impacted by climate shocks have a significantly lower probability of increasing their total productive investment. (2) In terms of investment content, climate shocks will reduce farmers' investment in machinery (invest1) and investment in the cost of seeds, fertilizers and pesticides (invest3) and increase investment in agricultural productive services (invest2). (3) However, there is heterogeneity in the village climate characteristics and farmers' risk preferences in this result. (4) From the perspective of the transmission mechanism, village public production investment has a moderating effect between climate shocks and farmer agricultural production investment. For total investment and invest3, village public production investment will weaken the main effect of climate shock, significantly reduce the impact of climate shock, and alleviate the inhibitory effect of climate shocks on farmers' investment. Agricultural productive services (invest2) will strengthen the main effect of climate shocks and promote farmer households' agricultural productive service investment. The article finally concludes and discusses some policy implications.

Keywords: agricultural productive investment, risk perception, village public production investment, moderating effect, climate shocks

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INTRODUCTION

The first working report of the sixth assessment report of the Intergovernmental Panel on Climate Change (IPCC) pointed out that climate change is extensive, rapid and intensifying. The frequency and intensity of extreme heat events, marine heat waves and heavy precipitation have increased significantly (IPCC, 2021), which is another reminder of the urgency of action on climate change. While some regions benefit from climate change (e.g., in mid-to-high latitudes, where warming increases crop yields), the vast majority will be adversely affected by climate change, especially for farmers who depend on agricultural income (Reynaud et al., 2017; Mera, 2018; Hu and Zheng, 2021). China is located in the monsoon climate zone with the fastest rate of environmental change in the world, and the climate conditions vary greatly from year to year. Intensified climate change will lead to high temperature, drought, heavy precipitation and other extreme weather and frequent occurrence of diseases and insect pests, which may directly lead to greater vulnerability of China's agriculture (Zhou et al., 2021). The reason is that agriculture relies heavily on natural climatic levels, and high temperatures or a lack of water can inhibit crop growth and reduce yields, especially extreme weather such as droughts and floods, which can even lead to failure of agricultural harvests (Bhuvaneswari et al., 2014).

In the long term, climate change will also affect irrigation resources, soil quality and the natural communities on which agricultural production depends (Araya et al., 2020). Melting polar glaciers are causing sea level rise and reducing the availability of cultivated land (Paul et al., 2010). This indirectly affects the price of food and the household income of farmers (Bandara and Cai, 2014). Nguyen et al. (2020) also further confirmed that climate shocks have a significant impact on household income, investment and poverty by using rural household survey data in northeastern Thailand and central Vietnam. Therefore, in this context, it is of great significance to study the impact of climate shocks on agricultural investment and explore the adaptive measures of farmers to cope with climate change, which are of great significance to the realization of various goals, such as stabilizing agricultural production, ensuring food security, and reducing poverty (FAO, 2012).

Becker (2010) believes that changes in the external environment have a profound impact on people's preferences and choices. The more severe the impact of climate risk is, the greater the uncertainty in agricultural production. To reduce the adverse impact of climate change and extreme weather on agricultural production and farmers' livelihoods, farmers will consciously and rationally take some adaptive measures to reduce the risk of shocks (Chen et al., 2014; Xu et al., 2017). Specifically, on the one hand, farmers will reduce the impact of climate change on agricultural production by increasing the level of mechanization, improving irrigation facilities, and changing crop varieties. As Belton et al. (2021) found, investment in agricultural mechanization facilitates more timely and efficient planting and harvesting, and these advantages help farmers to be more flexible in responding to risks in the context of labor shortages and changing climates. On the other hand, the use of agricultural machinery and the improvement of varieties are not only one of the ways to reduce climate risks through technological advantages but also a simple substitution of capital for agricultural labor under relative price constraints (Zhang et al., 2017). That is, under climate shock, the replacement of production factors such as labor, temperature, and precipitation by increasing agricultural input is also a rational choice for farmers to deal with climate change (Bhandari and Ghimire, 2016).

However, there are also views that climate shocks will prompt farmers to abandon agricultural production (Warner and Afifi, 2014; Cattaneo and Peri, 2016; Sheng and Yang, 2021). It has an inhibitory effect on farmers' agricultural investment. Based on opportunity cost theory (Hu X. et al., 2020; Geng and Luo, 2021), labor migration theory (Xu et al., 2020; Zeng et al., 2021) and the theory of comparative advantage (Hong and Luo, 2018; Hu W. et al., 2020), the formation mechanism of farmers' productive investment decision-making is analyzed. The logic of climate shocks reducing agricultural investment is that climate shocks will affect households through the income effect, which will gradually reduce farmers' dependence on agriculture, and the importance and expected returns of agricultural income will also decrease accordingly, thus prompting farmers to reduce agricultural investment. It can be seen that the existing conclusions on the impact of climate shocks on farmers' productive investment are inconsistent. The reason may be that there are differences in the research perspective and the definition of farmers' investment. Therefore, seemingly contradictory conclusions are drawn, and further discussion is necessary.

To respond to the above questions and explore farmers' adaptation behaviors to climate change, this study matched the macrolevel climate data with the microlevel peasant household data, focused on the impact of climate shock on agricultural productive investment, and investigated the internal logic, mechanism of action and heterogeneity of this impact. Thus, the impact of climate change on productive investment in agriculture can be estimated more reliably. It should be emphasized that although our research is based on Chinese data, its conclusions may have a certain reference for other developing countries in terms of coping with the impact of climate risks on agriculture, especially those countries in sub-Saharan Africa.

DATA AND METHODS

Data

This study applies two databases. The first is the farmer household survey data at the micro level. The data come from the China Family Panel Studies (CFPS) of Peking University. CFPS covers 25 provinces (municipalities and autonomous regions) in mainland China and adopts a three-stage unequal probability cluster sampling design. The data used in this article are mainly from CFPS2018 released in 2020, and only samples who live in rural areas and are still engaged in agricultural production in that year are retained. To obtain more comprehensive farmer household information, our research combined CFPS2016, CFPS2014, and CFPS2012 data with CFPS2018 data[1]. Only the information of rural households and members who participated in the four questionnaires was retained to obtain sample community information, cultivated land information and changes in agricultural investment. After processing, 23 provinces (cities/autonomous regions), 109 counties (districts), 243 villages, and a total of 2,799 valid samples were obtained.

The second is macrolevel climate data. The data come from the 2014, 2015, and 2016 "China Environmental Statistical Yearbook" and "China Statistical Yearbook." The main variables used are the provincial GDP and economic losses caused by extreme weather after earthquake disasters, including droughts, floods, and low temperatures, freezing, storms, marine disasters,

[1]This article uses cross-sectional data, and the purpose of merging is to fill in missing values.

etc. Compared with previous studies, the data coverage of this article is wider and more representative at the national level.

Variables

Explained Variable

Taking into account the above literature and data availability, this study focuses on three types of agricultural productive investment. The first is fixed investment that is not directly related to land. This study uses the added value of the total value of various types of agricultural machinery owned by farmers in that year. The second is the investment in agricultural productive services, including hire labor, hire livestock, machine rental, etc. This study uses the total value of the investment in hire labor and hire machinery. The third is investment in basic agricultural means of production with liquidity directly related to land, including seeds, fertilizers and pesticides. The total amount of the three types of investment is taken as the total scale of agricultural investment. In addition, Chinese farmers generally have diversified planting (Lu and Hu, 2015). In addition, some production investments (such as fixed assets) have difficulty accurately corresponding to the production of each crop, so this article does not distinguish between crop types. At the same time, considering that the household is the basic unit of agricultural production and management, the agricultural productive investment and other variables in this article are all taken as the statistical unit of the household, and the data are standardized.

Core Explanatory Variables

Climate Shock Index

The National Meteorological Administration lists floods, droughts, freezing disasters (mainly frost disasters) and wind disasters as the most important meteorological disasters, and the National Bureau of Statistics Poverty Monitoring Survey also lists and counts these disasters separately. There is a strong correlation between climate shocks and economic losses (Wasko et al., 2021). Considering the rationality and possibility of research needs and existing data, this article refers to the method of the disaster intensity index[2] and Xu et al. (2021). The amount of damage caused by natural disasters accounts for the proportion of GDP to measure the impact of climate shocks throughout the year (In order to facilitate the calculation, this article processes this ratio by ×100). Using relative value rather than absolute value indicators is conducive to measuring the impact of disaster losses on different regions according to local conditions. Of course, this article will also use the absolute loss value of climate shocks to test the robustness of the relationship between climate shocks and agricultural productive investment.

Control Variables

To improve the reliability of the fitted regression, this study introduces a series of control variables with reference to the existing literature. It mainly includes 13 control variables in three dimensions (**Table 1**): family demographic characteristics, family asset characteristics, and village characteristics. (1) Family demographic characteristics: This study selects four variables: family size, the number of household laborers, average age and average education level. (2) Family asset characteristics: on the one hand, considering whether to invest in agricultural production, a critical factor is the investment ability of the household (Huang and Ji, 2012). Therefore, this study uses the characteristics of farmers' household assets to represent the wealth level and economic ability of farmers. Specifically, it includes the value of financial assets, non-mortgage financial liabilities, per capita annual household income, and whether government subsidies are received. On the other hand, the scale of land management is a key variable affecting production investment. A larger management area means that farmers need to invest more liquidity assets (Hong, 2019; Yang and Ji, 2021). Therefore, this study also takes into account two factors, the scale of self-owned land and the scale of contracted land, which can reflect the characteristics of land assets. (3) Village characteristics: The terrain will affect the investment behavior of farmers by affecting the difficulty of farming, and the traffic situation will affect the investment behavior of farmers by affecting the acquisition of production materials. Therefore, this study refers to Qian and Qian (2018) to introduce the variables of village topography, traffic conditions and infrastructure at the village level. In addition, to control the possible influence of regional-level factors, this study controls the province fixed effect. The definitions of the key variables are displayed in **Table 1**.

Model

To analyze the impact of climate shocks on farmers' productive investment, the benchmark model is set as follows:

$$Investment_i = \alpha_0 + a_1 CS_i + a_2 Family_i + a_3 Asset_i + a_4 Village_i + \delta_1 P + \varepsilon_i \quad (1)$$

where $Investment_i$ indicates the agricultural production investment of farmers' households, CS_i is the Climate Shock Index, $Family_i$ is family demographic characteristics, $Asset_i$ is family asset characteristics, $Village_i$ is village characteristics, P is the province dummy variable to control the possible impact of regional-level factors, and ε_i is a random disturbance term. The main concern of this study is the coefficient of a_1, the impact of the climate shock index on the investment of farmers. To further examine whether there are differences in investment types due to climate shocks, this study will use Equation (1) to examine the impact of climate risk shocks on different investment types (Invest1, Invest2, and Invest3).

$$Investment_i = \beta_0 + \beta_1 CS_i + \beta_2 \cdot CS_i \cdot Vinvest_i + \beta_3 Vinvest_i + \beta_4 Control + \delta_2 P + \varepsilon_i \quad (2)$$

As an external risk-resistant factor, village productive investment can moderate the relationship between climate shocks and farmers' productive investment (**Figure 1**). Drawing on the research method of Wen et al. (2005). On the basis of Equation (1), this study introduces the interaction term between

[2]"14th Five-Year" National Emergency System Planning http://www.gov.cn/zhengce/content/2022-02/14/content_5673424.htm?spm=C73544894212.P59511941341.0.0.

TABLE 1 | Variable definition.

Variable	Variable definition	Mean
Invest1	Increased cost of agricultural machinery (yuan)	−0.010
Invest2	The cost of agricultural productive services (yuan)	0.097
Invest3	The cost of seeds, fertilizers and pesticides (yuan)	0.134
Invest total	Total agricultural productive investment (yuan)	0.319
CS	Climate shock index × 100	0.757
Family size	Family size	1.299
Num_labor	Number of household labor (15 < age < 60)	2.068
Avg_age	Average age of family members	3.837
Avg_edu	Average education level of family members (average years of schooling)	6.232
Ln_assets	The value of financial assets (yuan)	6.957
Ln_debt	The value of non-mortgage financial liabilities (yuan)	2.520
Ln_income	Per capita annual household income (yuan)	8.742
Allowance	Whether government subsidies are received (yes = 1, no = 0)	0.725
Land	The scale of self-owned land (mu)	12.214
Ln_rent	The scale of contracted land (yuan)	0.992
Ln_distance	The distance from county seat (the time it takes to travel normally)	0.329
Ln_infra	Amount of infrastructure investment (yuan)	0.355
Terrain	Hills = 1, Mountains = 2, Plains = 3, Others = 0	1.862

TABLE 2 | Climate shock index by province (2014–2016).

Province	2014	2015	2016	Province	2014	2015	2016
Shanghai	0.000	0.014	0.001	Qinghai	0.404	0.496	0.665
Tianjin	0.008	0.000	0.020	Jilin	0.849	0.582	0.668
Beijing	0.049	0.006	0.065	Shanxi	0.398	0.809	0.833
Shandong	0.138	0.128	0.107	Hunan	0.764	0.438	0.841
Guangxi	1.223	0.289	0.150	Yunnan	0.763	0.963	0.924
Jiangsu	0.022	0.121	0.156	Inner mongolia	0.636	0.618	0.992
Guangdong	0.497	0.433	0.182	Heilongjiang	0.371	0.262	1.043
Liaoning	0.592	0.227	0.206	Gansu	1.090	0.907	1.243
Sichuan	0.584	0.433	0.233	Xizang	0.206	0.407	1.311
Chongqing	0.691	0.140	0.269	Guizhou	2.107	0.642	1.472
Henan	0.340	0.119	0.308	Fujian	0.189	0.728	1.644
Zhejiang	0.144	0.532	0.354	Hebei	0.459	0.361	1.930
Shanxi	0.528	0.403	0.404	Hainan	5.068	0.384	1.955
Ningxia	0.603	0.285	0.549	Anhui	0.141	0.540	2.311
Jiangxi	0.463	0.417	0.573	Hubei	0.248	0.278	2.564
Xinjiang	1.128	1.671	0.595				

the climate shock index and village-level productive investment $Vinvest_i$, examines its moderating effect β_2 on the impact of climate shock on farmer agricultural productive investment, and constructs the moderating effect Model (2).

RESULTS

Descriptive Statistics

Table 2 shows the measurement results of the climate shock index in each province from 2014 to 2016. Taking 2016 as an example, it can be seen that the top five climate shock indexes are: Shanghai (0.001), Tianjin (0.020), Beijing (0.065), Shandong (0.107), and Guangxi (0.150). It is mainly the provinces with small actual losses caused by climate shocks or strong anti-risk ability caused by high GDP. Fujian (1.644), Hebei (1.930), Hainan (1.955), Anhui (2.311), and Hubei (2.564) are in the bottom five. The above provinces are mainly caused by high disaster losses, but the actual loss value of Hainan is not high. It is due to its low GDP and weak anti-risk ability. From the 2014 to 2016 data, it can be seen that there are differences in the climate shock index in different years. Some provinces, such as Hainan, even showed significant differences in 2014 (5.068) and 2015 (0.384), which fully demonstrates the climate shock is uncertain.

Figure 2 shows the average level of the climate shock index from 2014 to 2016. It can be seen that Hainan has the highest average climate shock index, reaching 2.469, mainly due to the high value in 2014 (see **Table 3**). In addition, the provinces with high average climate shock index (0.75–1.40) are mostly concentrated in the northwest region (Xinjiang and Gansu), the southwest region (Yunnan and Guizhou), the central region (Hubei and Anhui), and Hebei and Fujian. Shandong and Jiangsu, which are major agricultural provinces, have low climate shock indices, which fully shows that climate shocks vary among provinces in China. Therefore, analyzing the impact of different climate shocks on farmers' investment behavior is of great significance for interregional resource allocation and policy formulation to combat climate change.

Are Climate Shocks Affecting Agricultural Productive Investment?

First, the OLS method is used to estimate Model (1) to examine whether the impact of climate shocks on agricultural productive investment exists (**Table 3**). Among them, Column (1) only considers the impact of the climate shock index on the agricultural productive investment of farmers; Columns (2–4) gradually control for family demographic characteristics, family asset characteristics and village characteristics. As expected, the coefficients of the climate shock index are all significantly

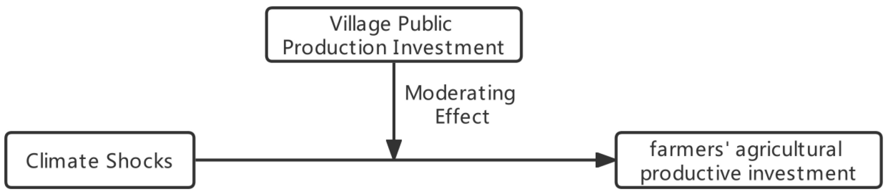

FIGURE 1 | Climate shocks, village public production investment, and farmers' agricultural productive investment.

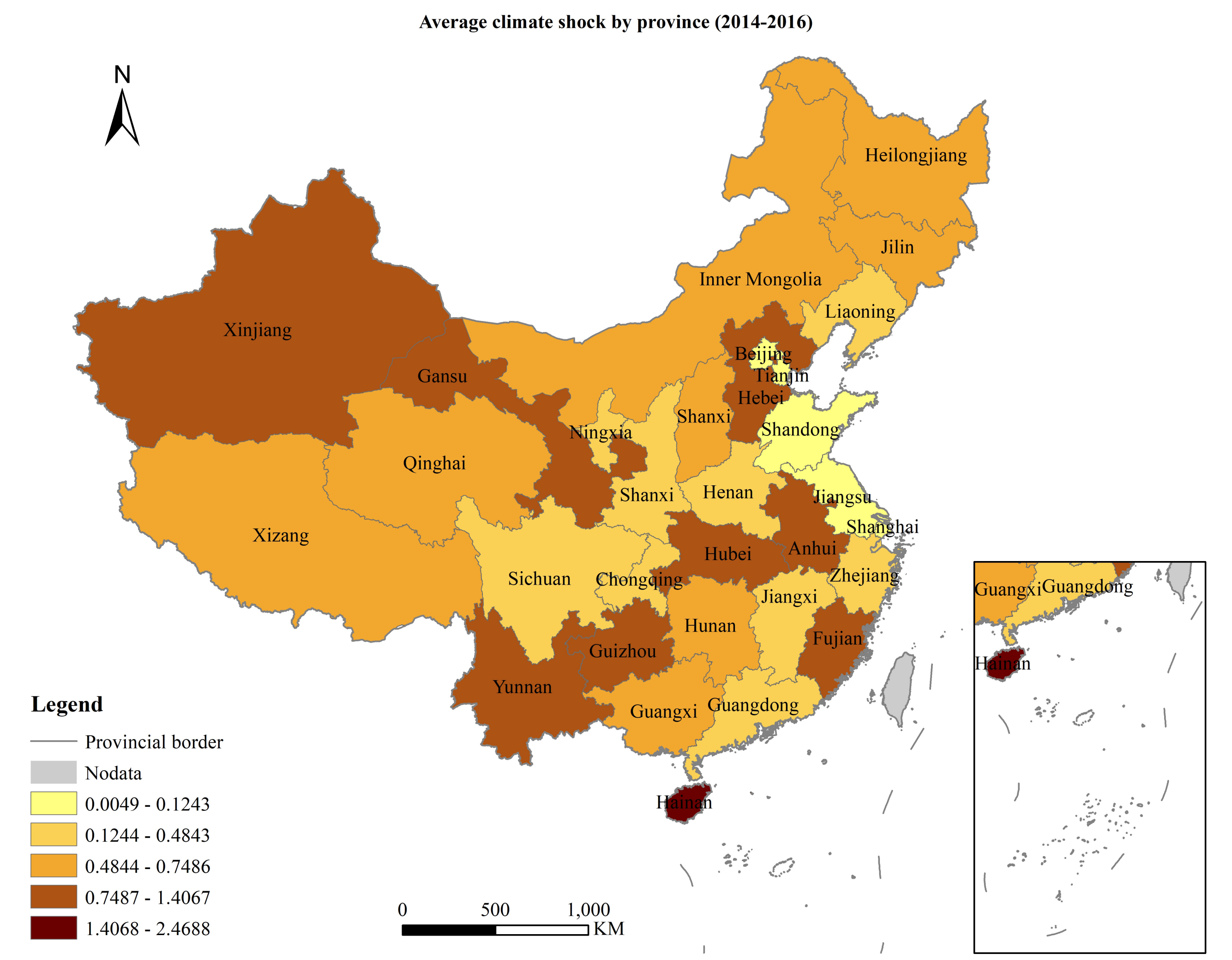

FIGURE 2 | Average climate shock by province (2014–2016).

negative in all regressions. This shows that, based on the benchmark model, the climate shock significantly reduces the total agricultural productive investment of farmers.

Among the control variables, family size and average education level in household demographic characteristics have significant promoting effects on agricultural productive investment. The larger the family size and the higher the average level of education, the greater the probability that farmers will invest in agricultural production. Among the characteristics of household assets, the value of household financial assets and non-mortgage financial liabilities have a significant role in promoting agricultural productive investment. It should be noted that the impact of the scale of family-owned land on agricultural productive investment is positive but not significant, but this is also expected. Under the household contract responsibility system policy, except for large-scale farms, there is little difference in the area of land owned by farmers (Xu and Zhang, 2016). In contrast, the impact of the scale of contracted land on agricultural productive investment of farmers is significantly positive because it is theoretically believed that the larger the scale of land, the more likely farmers are to increase capital investment to increase returns to scale (Xin and Qin, 2005). Therefore, the increase in the contracted land area will naturally encourage farmers to increase investment in agricultural mechanization and seed fertilizers (Li et al., 2021). Among village characteristics, the level of village infrastructure has a negative effect on agricultural investment, which may be due to the crowding-out effect of government investment on farmer investment. If the government's investment increases, the willingness of farmers to invest will decrease (Chu and Mo, 2011).

Are There Category Differences in the Impact of Climate Shocks on Agricultural Productive Investment?

The above estimates suggest that climate shocks can have an impact on agricultural productive investment. In this section, we examine whether there are differences in the impact of climate shocks on different types of productive investment. **Table 4** shows that climate shocks reduce farmers' investment in machinery (invest1), increase investment in agricultural productive services (invest2), and reduce investment in the cost of seeds, fertilizers and pesticides (invest3). What is different from the results in **Table 4** is the promotion effect of climate shocks on investment in agricultural productive services. This may be because farmers only make agricultural investments when they expect returns (Beekman and Bulte, 2012). In production practice, as the demander of agricultural machinery operations, there are mainly two ways for farmers to operate agricultural machinery. One is the self-service of self-purchased agricultural machinery. The second is the outsourcing method of leasing agricultural machinery. Compared with investment in productive services, investment in agricultural machinery has higher sunk costs and a long break-even period (Qiu et al., 2021). In particular, climate shock is not conducive to the survival of small farmers. Agricultural machinery has the characteristics of high investment costs, high technical thresholds and long payback periods, which reduce farmers' willingness to invest (Hong et al., 2020). In recent years, to meet the needs of small-scale farmers for agricultural machinery, specialized agricultural machinery service organizations have emerged in large numbers in rural areas, and many labor-intensive production links have been outsourced and mechanized. Therefore, farmers under climate shock are more inclined to increase investment in agricultural productive services. This is consistent with the existing research conclusions and in line with the actual situation of current agricultural production.

Robustness Tests

Climate shock is relatively exogenous to farmers' productive investment, which alleviates the endogenous problem of core explanatory variables to a certain extent. Therefore, to ensure the reliability of the above regression results, further robustness tests are carried out from the following three aspects. First, referring to the practice of Crinò and Ogliari (2015), to address the potential measurement error problem and prevent outliers from biasing the core results, this article performs bilateral truncation on the 1% quantile of the climate shock index. The results are shown in **Table 5**. The impact of the core explanatory variable climate shock index on agricultural productive investment remains unchanged and still significant.

Another concern is that there are certain differences in the impact of climate shocks on farmers' behavior in different years, which may lead to differences in the impact of agricultural productive investment. Therefore, to further test the robustness of the research conclusions, this study selects the average value of the climate shock index (2014, 2015, and 2016) as the core explanatory variable, and the regression results are shown in **Table 6**. After replacing the core explanatory variables, the influence coefficients of the climate shock index on invest1 (agricultural machinery investment), invest2 (agricultural productive services investment), and invest3 (the investment of seeds, fertilizers, and pesticides) have slightly increased, but the direction of influence is consistent with **Table 3** and remains significant. This further confirms the robustness of the results of the impact of climate shocks on agricultural productive investment.

The climate shock index set in the benchmark model in this article is a relative variable, and for provinces with large differences in climatic conditions and GDP, it may not fully reflect the real situation of the level of climate shock. To further exclude possible interference, this study uses the economic loss value caused by the actual climate shock instead of the climate shock index for the robustness test. From **Table 7**, it can be found that after replacing this core explanatory variable, the influence coefficients of the climate shock index on invest1 (agricultural machinery investment), invest2 (agricultural productive services investment), and invest3 (the investment of seeds, fertilizers, and pesticides) are slightly reduced but still significant, which further confirms the robustness of the conclusions of this article.

Heterogeneity Analysis

Heterogeneity of Village

Will climate shocks in disaster-prone regions have a greater impact on productive investment? To confirm the above judgments, this article divides the overall sample into two subsamples, the climate safe area and the climate non-safe area, according to whether the village where the farmer is located in the CFPS questionnaire is an area with frequent natural disasters. Using the benchmark model, the above two subsamples are fitted and regressed, and the results are shown in **Table 8**. For farmers in climate-insecure areas, the coefficients of the impact of climate shocks on invest total (Total agricultural productive investment), invest1 (agricultural machinery investment), and invest3 (the investment of seeds, fertilizers, and pesticides) are still negative, which is consistent with the benchmark regression. However, for farmers in climate-safe areas, climate shocks will not have a significant impact on their agricultural productive investment. This also fully illustrates a problem. With the aggravation of climate change, it is necessary to pay more attention to the productive investment of farmers in climate-insecure areas with frequent natural disasters.

Heterogeneity of Risk Appetite

Classical economic theory believes that risk appetite will affect investment decisions. Therefore, this part focuses on examining the impact of farmers' risk attitude heterogeneity on agricultural productive investment. This study uses the behavior and mental state part of the CFPS2018 questionnaire to evaluate farmers' risk attitudes. The value of the risk attitude variable from 1 to 6 represents the increasing degree of risk preference of residents. If the variable value of risk attitude is greater than or equal to 4, it is classified as a risk-loving farmer; otherwise, it is classified as a risk-averse farmer. **Table 9** shows that for risk-averse farmers, the coefficients of the impact of climate shocks on invest total (Total agricultural productive investment), invest1 (agricultural machinery investment), and invest3 (the investment of seeds, fertilizers, and pesticides) are still negative, which is consistent with the benchmark regression. However, the negative impact of

TABLE 3 | Regression results of the benchmark model between climate shocks and farmers' agricultural investment.

	(1)	(2)	(3)	(4)
	Invest total	**Invest total**	**Invest total**	**Invest total**
CS	−0.0765* (0.0404)	−0.0853** (0.0417)	−0.1396*** (0.0446)	−0.0924* (0.0508)
Family size		0.0883*** (0.0287)	0.0898*** (0.0262)	0.0902*** (0.0266)
Num_labor		0.0108 (0.0115)	0.0011 (0.0116)	0.0010 (0.0117)
Avg_age		0.0480 (0.0903)	0.1250 (0.0821)	0.1144 (0.0815)
Avg_edu		0.0146*** (0.0035)	0.0143*** (0.0034)	0.0130*** (0.0034)
Ln_debt			0.0120** (0.0049)	0.0119** (0.0049)
Ln_assets			0.0078* (0.0041)	0.0076* (0.0042)
Ln_income			−0.0069 (0.0197)	−0.0077 (0.0195)
Allowance			−0.0393 (0.0336)	−0.0406 (0.0336)
Land			0.0002 (0.0003)	0.0004 (0.0003)
Ln_rent			0.0658*** (0.0111)	0.0655*** (0.0110)
Ln_distance				−0.0011 (0.0156)
Ln_infra				−0.0285* (0.0148)
Constant	0.3920*** (0.0008)	−0.0130 (0.3826)	−0.2649 (0.3794)	−0.2017 (0.3713)
Observations	2832.0000	2826.0000	2799.0000	2799.0000
R^2	0.0630	0.0746	0.1500	0.1566

*Standard errors of estimated coefficients are in parentheses. Significance relationships are shown as indicated by the p-values: *p < 0.10, **p < 0.05, ***p < 0.01. The other tables are the same.*

TABLE 4 | Impact of climate shocks on different types of productive investment.

	(1)	(2)	(3)	(4)	(5)	(6)
	Invest1	**Invest1**	**Invest2**	**Invest2**	**Invest3**	**Invest3**
CS	−0.0176*** (0.0064)	−0.0263*** (0.0082)	0.0570*** (0.0183)	0.0443* (0.0254)	−0.0639*** (0.0164)	−0.0675*** (0.0211)
Other control variables	NO	YES	NO	YES	NO	YES
Province-fixed effects	YES	YES	YES	YES	YES	YES
Observations	2799	2799	2799	2799	2799	2799
R^2	0.0125	0.0237	0.0164	0.0692	0.0909	0.1884

*To save space, this study will no longer report the regression results of other control variables, and readers who need it can ask the author for it. Standard errors of estimated coefficients are in parentheses. Significance relationships are shown as indicated by the p-values: *p < 0.10, **p < 0.05, ***p < 0.01.*

TABLE 5 | Robustness test 1: Bilateral truncation on the 1% quantile of the climate shock index.

	(1)	(2)	(3)	(4)	(5)	(6)
	Invest1	**Invest1**	**Invest2**	**Invest2**	**Invest3**	**Invest3**
CS	−0.0190*** (0.0069)	−0.0283*** (0.0088)	0.0613*** (0.0200)	0.0477* (0.0273)	−0.0688*** (0.0177)	−0.0726*** (0.0228)
Other control variables	NO	YES	NO	YES	NO	YES
Province-fixed effects	YES	YES	YES	YES	YES	YES
Observations	2799	2799	2799	2799	2799	2799
R^2	0.0125	0.0237	0.0164	0.0692	0.0909	0.1884

*Standard errors of estimated coefficients are in parentheses. Significance relationships are shown as indicated by the p-values: *p < 0.10, **p < 0.05, ***p < 0.01.*

climate shocks on agricultural investment is no longer significant for risk-loving farmers.

DISCUSSION

Village public production investment mainly includes investment in farmland water conservancy infrastructure, rural roads and public agricultural product storage and processing equipment. In addition to farmersŠ investment, village public production investment is also of great significance to improving farmersŠ income and enhancing the ability of agriculture to resist risks (Huang et al., 2006; Shibao et al., 2019). Therefore, this study will examine whether "village public production investment" can have a buffering effect under climate shocks; see Equation (2). This study selects "Last year, in your village's total financial expenditure, how much was used for production investment (agricultural water conservancy, etc.)" as the measure

TABLE 6 | Robustness test II: Replace the core explanatory variable with the average value of the climate shock index in the past 3 years.

	(1)	(2)	(3)	(4)	(5)	(6)
	Invest1	**Invest1**	**Invest2**	**Invest2**	**Invest3**	**Invest3**
Average CS	−0.0177*** (0.0064)	−0.0301*** (0.0093)	0.0570*** (0.0183)	0.0506* (0.0290)	−0.0640*** (0.0164)	−0.0771*** (0.0242)
Other control variables	NO	YES	NO	YES	NO	YES
Province-fixed effects	YES	YES	YES	YES	YES	YES
Observations	2799	2799	2799	2799	2799	2799
R^2	0.0125	0.0237	0.0164	0.0692	0.0909	0.1884

*Standard errors of estimated coefficients are in parentheses. Significance relationships are shown as indicated by the p-values: *p < 0.10, **p < 0.05, ***p < 0.01.*

TABLE 7 | Robustness test 3: Using actual disaster losses instead of the climate shock index.

	(1)	(2)	(3)	(4)	(5)	(6)
	Invest1	**Invest1**	**Invest2**	**Invest2**	**Invest3**	**Invest3**
Economic loss	−0.0067*** (0.0024)	−0.0100*** (0.0031)	0.0217*** (0.0070)	0.0169* (0.0096)	−0.0243*** (0.0063)	−0.0257*** (0.0080)
Other control variables	NO	YES	NO	YES	NO	YES
Province-fixed effects	YES	YES	YES	YES	YES	YES
Observations	2799	2799	2799	2799	2799	2799
R^2	0.0125	0.0237	0.0164	0.0692	0.0909	0.1884

*Standard errors of estimated coefficients are in parentheses. Significance relationships are shown as indicated by the p-values: *p < 0.10, **p < 0.05, ***p < 0.01.*

TABLE 8 | Climate shocks and farmers' productive investment: Heterogeneity of village.

	Invest total	**Invest1**	**Invest2**	**Invest3**
		Climate insecure zone (*N* = 2186)		
CS	−0.1255** (0.0534)	−0.0206** (0.0089)	0.0394 (0.0302)	−0.0835*** (0.0198)
[-1.2pt] Other control variables	YES	YES	YES	YES
R^2	0.1639	0.0292	0.0771	0.1993
		Climate safe zone (*N* = 605)		
CS	0.0868 (0.1218)	0.0476 (0.0306)	0.0665 (0.0486)	0.0207 (0.0514)
Other control variables	YES	YES	YES	YES
R^2	0.1532	0.0615	0.0631	0.1725

*Standard errors of estimated coefficients are in parentheses. Significance relationships are shown as indicated by the p-values: *p < 0.10, **p < 0.05, ***p < 0.01.*

TABLE 9 | Climate shocks and farmers' productive investment: Heterogeneity of risk attitudes.

	Invest total	**Invest1**	**Invest2**	**Invest3**
		Risk-averse farmers (*N* = 2290)		
CS	−0.0946* (0.0547)	−0.0251*** (0.0082)	0.0469 (0.0305)	−0.0697*** (0.0207)
Other control variables	YES	YES	YES	YES
R^2	0.1509	0.0303	0.0697	0.1813
		Risk-loving farmers (*N* = 605)		
CS	−0.1174 (0.1418)	0.0315 (0.0340)	−0.0196 (0.0616)	−0.0557 (0.0636)
Other control variables	YES	YES	YES	YES
R^2	0.2583	0.0497	0.1644	0.2806

of the village's public production investment. **Table 10** shows the regression estimation results. Column (1) shows that the coefficient of interaction between climate shocks and village public production investment variables is significantly positive, indicating that village public production investment can indeed alleviate the adverse impact of natural disasters on farmers' productive investment and has a certain incentive effect on farmers' investment.

Specifically, for invest total (Total agricultural productive investment) and invest3 (the investment of seeds, fertilizers, and pesticides), the coefficient of the cross term of climate shock and village public production investment is negative, and the sign is the same as that of the core explanatory variable climate shock coefficient, indicating that village public production investment will significantly weaken the main effect of climate shocks on investment impacts. For invest2 (agricultural productive services

TABLE 10 | Climate shocks and village public production investment: Moderating effects of village-level infrastructure investment.

	(1)	(2)	(3)	(4)
	Invest total	**Invest1**	**Invest2**	**Invest3**
CS	−0.0558 (0.0672)	−0.0276*** (0.0090)	0.0639** (0.0286)	−0.0555* (0.0295)
CS × village investment	0.0007*** (0.0003)	−0.0000 (0.0001)	0.0004*** (0.0001)	0.0002** (0.0001)
Village investment	−0.0012*** (0.0004)	0.0000 (0.0001)	−0.0006*** (0.0002)	−0.0004** (0.0002)
Other control variables	YES	YES	YES	YES
Province-fixed effects	YES	YES	YES	YES
N	2799	2799	2799	2799
R^2	0.1560	0.0237	0.0690	0.1875

*Standard errors of estimated coefficients are in parentheses. Significance relationships are shown as indicated by the p-values: *p < 0.10, **p < 0.05, ***p < 0.01.*

investment), the coefficient of the multiplication term is positive, and the sign of the core explanatory variable climate shock coefficient is the same, which will significantly strengthen the main effect of promoting investment. A possible explanation is that investment in village public production is external, and investment in village public production will reduce the production cost of farmers. In other words, if the investment in the village's public production builds a new reservoir in the village, farmers can obtain irrigation water by simply increasing the field irrigation facilities, and then the phenomenon of "coinvestment" will appear and exert the "crowding-in effect (Cremades et al., 2015)."

CONCLUSION AND RECOMMENDATIONS

This article comprehensively reviews the theoretical mechanism of climate shock on agricultural productive investment and conducts empirical analysis and mechanism discussion based on nationally representative CFPS data. The study found the following: (1) Climate shocks have a significant impact on farmers' productive investment choices. Farmers who are greatly impacted by climate risks have a significantly lower probability of increasing their total investment (Total agricultural productive investment). In terms of investment content, climate shocks will reduce farmers' investment in invest1 (agricultural machinery investment) and invest3 (the investment of seeds, fertilizers, and pesticides) and increase farmers' investment in invest2 (agricultural productive services investment). An important reason for the current academic debate about climate shocks promoting or inhibiting farmers' productive investment is that they ignore the differences in investment types. (2) The impact of climate shocks on farmers' productive investment shows a certain degree of heterogeneity, and farmers in climate-insecure areas and risk-averse farmers are more susceptible to climate risk shocks. (3) From the perspective of the impact mechanism, investment in village public production has a moderating effect on the relationship between climate shocks and agricultural productive investment. Specifically, for invest2 (agricultural productive services investment), village public production investment will strengthen the main effect of climate shocks and enhance the promotion of farmer investment; for invest3 (the investment of seeds, fertilizers, and pesticides), village public production investment will weaken the main effect of climate shock and ease the inhibitory effect on investment.

Based on the above findings, this article draws the following implications. First, for government departments, it is necessary to assess climate risks in a timely manner and reduce carbon emissions and to pay attention to the decision-making behaviors affected by changes in the sentiment of agricultural investors caused by climate shocks. This focus needs to pay attention to the impact of farmers' demand for productive services in the context of climate shocks and provide microcredit support to meet farmers' investment needs in times of crisis (Yagura, 2020). At the same time, promote the establishment of a service outsourcing system that supports the diversified production needs of farmers, and guides the effective connection of supply and demand through the construction of relevant mechanisms and platforms, reduces transaction costs, and alleviates the dilemma of the lack of service outsourcing supply. Second, for villages with frequent large-scale natural disasters, accelerate the process of marketization of rural land transfer, optimize the allocation of rural production factors and resources, and opportunities such as non-agricultural employment are provided to increase the income of farmers, to alleviate the inhibitory effect of climate shocks on agricultural productive investment. The most important thing is that reducing risks can lead to higher investment (Karlan et al., 2014). It is necessary to pay attention to the corresponding infrastructure construction for rural disaster prevention and resilience and to strengthen the coverage ratio of agricultural insurance (Xu et al., 2019), fundamentally improving farmers' security level under climate shocks.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: http://www.isss.pku.edu.cn/cfps/.

AUTHOR CONTRIBUTIONS

ZZ 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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