

Research Article

Human Capital and Rural Households' Vulnerability to Relative Poverty: Evidence from China

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Drawing on three-wave panel data from China Family Panel Studies (CFPS) of 2014, 2016, and 2018, this paper measures rural households' vulnerability to relative poverty using the three-stage feasible generalized least squares (FGLS) model. We analyze the impact of human capital on vulnerability to relative poverty by using the two-way fixed-effect model and panel quantile regression. Empirical results exhibited that labor force migration, health, education, and working experience all have a negative effect on vulnerability to relative poverty. Labor force migration has the greatest negative effect among the four factors. Heterogeneity analysis results exhibited that labor force migration has the biggest negative effect in the east region. Health and education have the greatest negative impact in the central region. Labor force migration, health, work experience, and education have a greater effect on nonpoor households than on poor households.

1. Introduction

Poverty is a great challenge that all countries face in the world [1]. In 1986, China began to carry out poverty alleviation work in an organized and planned way [2]. Great results have been achieved so far. China has completed the goal of eradicating absolute poverty by 2020 as scheduled. But it does not mean that China's poverty alleviation work is over [3]. In the postpoverty alleviation era, China's poverty reduction will face a new challenge: the relatively poor people will become the main body of poverty [4]. Relative poverty alleviation also meets the requirement of high-quality development in China [5]. Relative poverty puts more emphasis on a vulnerability of "sense of relative deprivation." Relative poverty has the characteristics of continuity, subjectivity, as well as dynamics, inequality, and relativity. Most existing studies identify poverty from a multidimensional perspective [6–8]. In December 2020, the Central Economic Work Conference pointed out that the government should consolidate and expand the achievements of poverty

alleviation and resolutely prevent large-scale poverty return. At present, the global COVID-19 situation is still grim, and various sudden risk shocks are testing the risk management and coping abilities of families. The economic impact brought by the epidemic will cause greater harm to vulnerable groups and aggravate inequality and social class differentiation. Poverty is an important issue closely related to sustainable development and an important indicator of social and economic development [9]. At present, the government often uses the income poverty standard to calculate the headcount ratio to measure poverty. The poverty index is a static measure of a household's well-being at a particular time [10]. There are limitations in antipoverty policies made by the government based on the incidence of poverty. The headcount ratio is merely an ex post measure that does not take the household's future welfare and associated risks into account. Therefore, the poverty incidence rate cannot dynamically reflect future poverty trends of households and ignore the current households in nonpoverty status that are more likely to fall into poverty in the future [11].

The World Bank defines vulnerability to poverty as the possibility of a person or family's welfare decreasing to a certain socially accepted level under risk shocks in the future [12].

Vulnerability to poverty pays more attention to the long-term and dynamic nature of poverty, the stability of poverty reduction, and the possibility of returning to poverty [13]. It not only reflects the reality of current poverty but also depicts poverty deeply and dynamically. Poverty vulnerability overcomes the deficiency of the headcount ratio in measuring the economic status of households in the future. The government can identify households at risk of falling into poverty in the future by introducing the vulnerability to poverty measurement, which helps the government formulate effective preintervention policies for families or regions with high vulnerability to poverty. In addition, considering the influencing factors of vulnerability to poverty under the background of poverty alleviation has important guiding significance for improving the endogenous development motivation of households in relative poverty status.

Development economics theory points out that the crux of poverty problems such as backward national economic development and low level of national income lies in the lack of capital. Since then, scholars began to focus on the impact of human capital on poverty. From a macro point of view, the crux of poverty and backwardness in underdeveloped countries lies in the lack of human capital stock [14]. Endogenous growth theory also emphasizes the role of human capital in economic growth, thus laying a foundation for the poverty reduction effect of human capital [15]. From the micro point of view, some scholars believe that human capital can increase income [16]. Sen pointed out that low human capital, such as education and health, deprived individuals' ability to obtain income, thus leading to individual poverty [17]. Bawono analyzed household data in Indonesia during 1984–2019 and found that education can effectively increase income and reduce the rural poverty rate [18]. Brown found higher education can lead to poverty reduction [19]. Working experience can positively affect households' income, and the rate of return increases with increasing income [20]. Guo pointed out that rural labor migration can also effectively alleviate rural poverty [21]. However, some scholars have found that human capital has no significant impact on increasing income. Wedgwood analyzed data in Tanzanian and found that education failed to improve rural income and alleviate poverty [22]. Moeis et al. think simply moving out of agriculture does not guarantee that farmers, especially landless farmers, will become better off [23].

Most existing studies focus on the relationship between human capital and poverty stock [24, 25]. This is an analysis that statically measures the level of well-being of households at a particular time and does not extend the research perspective to vulnerability to poverty, which takes future risks into account. In addition, most of the existing literature focuses on the study of human capital on households' income, but few studies find that human capital can affect the vulnerability to poverty. Gloede found that risk shock would significantly increase farmers' risk avoidance probability in

Thailand and Vietnam, and education could improve farmers' ability to avoid the risk of falling into poverty, that is to say, reduce their vulnerability to poverty [26]. By analyzing data from Vietnam and India, Imai found that education level would increase nonagricultural employment opportunities and then reduce vulnerability to poverty [27]. Chen analyzed data from China's Ministry of Civil Affairs and found the most vulnerable areas are concentrated in western China and human resources have some mitigating effect on poverty [28].

Vulnerability to poverty can estimate the probability of occurrence of households in the future and make up for the inadequacy of income poverty standard and improve the pertinence of poverty alleviation resources utilization. As an important method of antipoverty, human capital plays an important role in enhancing the sustainable development capacity of the poor population. Increasing human capital poverty alleviation is of great significance to the implementation of targeted poverty alleviation and the promotion of urban-rural integrated development under the new situation and helps the government reshape the poverty alleviation policy system.

Existing studies have recognized the effect of human capital on rural poverty reduction, but no consistent conclusions have been drawn. Most studies choose to study from the perspective of income growth, but we identify the impact of human capital on the relative poverty of farmers from the perspective of poverty vulnerability, providing a quantitative basis for the government to formulate policies. In terms of variable selection, most of the existing studies have chosen a single variable to represent human capital, such as the education and health. There are few studies on the relative poverty of rural households focusing on education, health, work experience, and labor migration at the same time. In terms of research data and methods, some studies usually adopt regional micro data or sectional data and use the OLS model for quantitative analysis. In addition, these studies seldom distinguish the difference in human capital's impact on households with different levels of vulnerability to relative poverty.

In the long run, the quality of poverty alleviation can be improved, and substantial progress can be made only by improving the sustainable development capacity of poor rural areas and populations. Promoting human capital accumulation in poor areas and forming a positive interaction mechanism with economic growth not only can directly reduce poverty but also can limit the negative effect of widening the income gap on poverty reduction. Inspired by these concerns, this study utilized three-wave data from China (2014, 2016, and 2018) to construct measures of vulnerability to relative poverty of households. We integrate education, health, work experience, and labor force migration into the analysis framework and analyze the impact of human capital on the vulnerability to relative poverty of rural households by using panel two-way fixed-effects regression and quantile regression. Furthermore, the effects of different dimensions of human capital on different relative poverty vulnerabilities are compared.

The remainder of the paper is structured as follows. The next section explains the methodology employed to determine the extent and nature of a household's vulnerability to relative poverty. Section 3 describes the data and variables used in the study. Section 4 discusses the estimation results, and Section 5 is conclusions. The final section concludes the paper.

2. Methods

2.1. Vulnerability to Relative Poverty Estimation. We adopt the definition of VEP and measure the vulnerability to relative poverty of rural households in China. Vulnerability as expected poverty (VEP) refers to the probability that households' expected future income is lower than the set poverty line [29]. According to this definition, vulnerability to poverty of households comes from the distribution characteristics of future income of households. Both their welfare expectation and welfare fluctuation are determined by family characteristic variables. The estimation method of vulnerability to relative poverty is as follows:

First, we define the vulnerability to relative poverty of household i in period t is: $Vul_{it} = prob(\ln Y_i \leq \ln \text{poor} | X_i)$, that is, the probability that a household's future per capita income is less than the set relative poverty line. It is generally believed that the income characteristics of high-income groups conform to the Pareto distribution, while the log-normal distribution is more suitable to describe the situation of low-income groups. Therefore, income needs to be taken natural logarithmic process.

$$\ln Y_{it} = \alpha_i X_{it} + e_{it}. \quad (1)$$

where X_{it} is a set of observable variables affecting household income and e_{it} is the residual term. We use the three-stage least-squares method [30] to weighted regress the logarithm of per capita income and the square of the residual term in formula (1) to get asymptotic efficient estimators $\hat{\alpha}_{FGLS}$ and $\hat{\beta}_{FGLS}$. According to the FGLS estimator, we estimate the expectation and variance of logarithms of a household's future per capita income.

$$\begin{aligned} \hat{E}(\ln Y_i | X_i) &= X_i \hat{\alpha}_{f g l s}, \\ \hat{V}(\ln Y_i | X_i) &= \sigma_{e,i}^2 = X_i \hat{\beta}_{f g l s}. \end{aligned} \quad (2)$$

We assume that the logarithm of income obeys normal distribution [31]. Then we select the appropriate relative poverty line to calculate the rural household's vulnerability to relative poverty as follows:

$$vul_{i,t} = prob(\ln Y_{i,t+1} < \ln \text{poor}) = \phi\left(\frac{(\ln \text{poor} - X_i \hat{\alpha}_{f g l s})}{\sqrt{X_i \hat{\beta}_{f g l s,i}}}\right). \quad (3)$$

2.2. Empirical Strategy. We use the two-way fixed-effects model and panel quantile model to analyze the impact of human capital on rural households' vulnerability to relative poverty as follows:

$$Vul_{it} = \omega_0 + \omega_1 \text{edu}_{it} + \omega_2 \text{hea}_{it} + \omega_3 \text{workexp}_{it} + \omega_4 \text{img}_{it} + \nu X + u_i + \lambda_t + \varepsilon_{it}. \quad (4)$$

$$Q_{Vul_i}(\tau|x) = \eta_0 + \eta_1 \text{edu}_{it} + \eta_2 \text{hea}_{it} + \eta_3 \text{workexp}_{it} + \eta_4 \text{img}_{it} + \kappa X + u_i + \lambda_t + \varepsilon_{it}. \quad (5)$$

We also use the four dimensions of human capital to calculate the rural households' human capital index. The weight of each dimension is calculated by the entropy method. The calculation procedure is as follows:

$$Vul_{it=0} + \omega_1 \text{hindex}_{it} + \nu X + u_i + \lambda_t + \varepsilon_{it}. \quad (6)$$

In formulas (5)–(7), Vul_{it} is vulnerability to relative poverty of rural household i in time t . $Q_{Vul_i}(\tau|x)$ is vulnerability to relative poverty of rural household i in time t conditional quantile function quantile τ under given independent variables. edu_{it} , hea_{it} , workexp_{it} , and img_{it} are average years of education, average health level, average work experience, and the proportion of migrant workers in rural household i , respectively. X is a set of control variables. u_i is the individual fixed effect that controls the problem of missing variables in households that do not change over time. λ_t is the time fixed effect that controls an individual's heterogeneity in time trend. ε_{it} is a random disturbance term.

We also calculate the human capital index. In formula (7), hindex_{it} represents the human capital index of household i at time t . The human capital index used in this study had a different base and included positive indexes. Therefore, min-max normalization was employed to normalize the raw data for each index as previously described. In order to avoid the deviation caused by information overlap and subjective weighting, the human capital index is synthesized; we use the entropy method to calculate the weight of objective indicators and then synthesize the human capital index. The synthesis steps are as follows:

(1) Standardize the data:

$$X'_{ij} = \frac{X_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)}. \quad (7)$$

(2) Calculate the entropy information of the human capital index of the j -th dimension:

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^m (Y_{ij} \times \ln Y_{ij}), \quad (8)$$

$$Y_{ij} = \frac{X'_{ij}}{\sum_{i=1}^m i'}$$

The coefficient of variation t of the j -th dimension human capital index is

$$\nu_j = 1 - e_j. \quad (9)$$

The index weight is

$$W_j = \frac{v_j}{\sum_{j=1}^n v_j}. \quad (10)$$

Human capital index of household i is

$$\text{hcindex}_i = \sum_{j=1}^n W_j \times X'_{ij}. \quad (11)$$

3. Data and Descriptive Statistics

3.1. Data. The data used for the analysis are three-wave panel data from China Family Panel Studies (CFPS) of 2014, 2016, and 2018. The related survey began in 2010. There have been five rounds of data (2010, 2012, 2014, 2016, and 2018) so far. The CFPS data samples have been covering individuals and households in 146 administrative villages in 105 counties (districts and county-level cities) in 25 provinces (provinces/municipalities/autonomous regions) that are reflecting the development of China's social population, economy, education, and health. Due to the lack of indicators of households' labor mobility in the 2012 survey, this paper selects data from surveys from 2014 to 2018 to investigate the impact of human capital on vulnerability to relative poverty of rural households in China. In the process of data cleaning, the author only retained peasant household samples that participated in more than two consecutive surveys.

3.2. Variables

3.2.1. Human Capital. We select four dimensions of health, education, work experience, and migration of labor force to represent rural household's human capital. The labor force excludes workers who are of working age but out of work and workers who are older than 65. The former cannot bring income to their families because they are in school or not in the labor market. The latter only can make up for the lack of family expenses by doing odd jobs due to family poverty. Their abilities to get income are very volatile. Health refers to the average health level of the household's labor force, which is calculated based on the answers to the question "self-rated health status" (in the questionnaire, there are five options for self-rated health status: unhealthy, general, relatively healthy, healthy, and very healthy, with the corresponding values ranging from 1 to 5. The higher the score, the healthier the person) in the questionnaire. Education refers to the average years of education received by the households' labor force. As for work experience, we use the age of the labor force minus the years of education and the preschool age to calculate the years of working to represent working experience. As for labor force migration, many scholars focus on the cross-area mobility of the rural labor force, that is, going out to work in cities. We measure the labor force migration by the proportion of the number of the labor force working in cities in the total labor force. hcindex_{it} represents the human capital index of household i at time t .

3.2.2. Vulnerability to Relative Poverty. A household's vulnerability to relative poverty is an ex ante indicator of household welfare that helps analyze which nonpoor households may fall into relative poverty in the future or which families that have been lifted out of relative poverty may fall into relative poverty and become poor again in the future. The difference between vulnerability to poverty and poverty is also inherent to the existence of risks. If families do not face risks, the state of household vulnerability to relative poverty and welfare risk management will be relatively stable over a certain period of time; nonpoor households will not fall into poverty; and families that have been lifted out of poverty will not return to poverty. As for the measurement of relative poverty, scholars have proposed two measurement standards, using a proportion of median income or average income as the measurement standard of relative poverty [32]. We adopt the OECD standard that is 50% of the median per capita income of the household. The household is identified in relative poverty if its per capita income is lower than this standard. We calculate that the relative poverty lines in 2014, 2016, and 2018 are 7,120 yuan/year, 8,540 yuan/year, and 8,499 yuan/year, respectively (at constant prices in 2010). Then we estimate vulnerability to relative poverty directly under the relative poverty standard.

3.2.3. Other Variables. Demographic, economic, and environmental characteristics of the head of household, household characteristics, and village characteristics are also included, for a total of 19 indicators across 3 categories. The corresponding characteristics for the head of household are age, age square, gender, years of education, and marital status. Household characteristics reflect the household situation and the extent to which the household can bear risk, captured through the aspects of social capital, material capital, financial capital, and other relevant indicators. The corresponding characteristics of households are social network, social status, social trust, drinking water, cooking fuel, land, car, house, financial products. The third category reflects the characteristics of the village to which the households belong. The corresponding characteristics of the village are whether there are high pollution enterprises within 5 kilometers of the village, whether the village is a mining area, whether the village is a minority area, and distance from the village to the county to which the village belongs (li).

3.3. Descriptive Statistics. We estimate vulnerability to relative poverty directly under the relative poverty standard. Results are shown in Figure 1. Vulnerability to relative poverty decreased from 2014 to 2018. However, vulnerability to relative poverty all exceeded 50% in these three years, indicating that the probability of rural households getting into the relative poverty trap in the future is still large. There is still a serious relative poverty problem among rural households in China. The eastern region (according to existing literature, the authors divide China into three areas: east region, central region, and west region. East region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai,

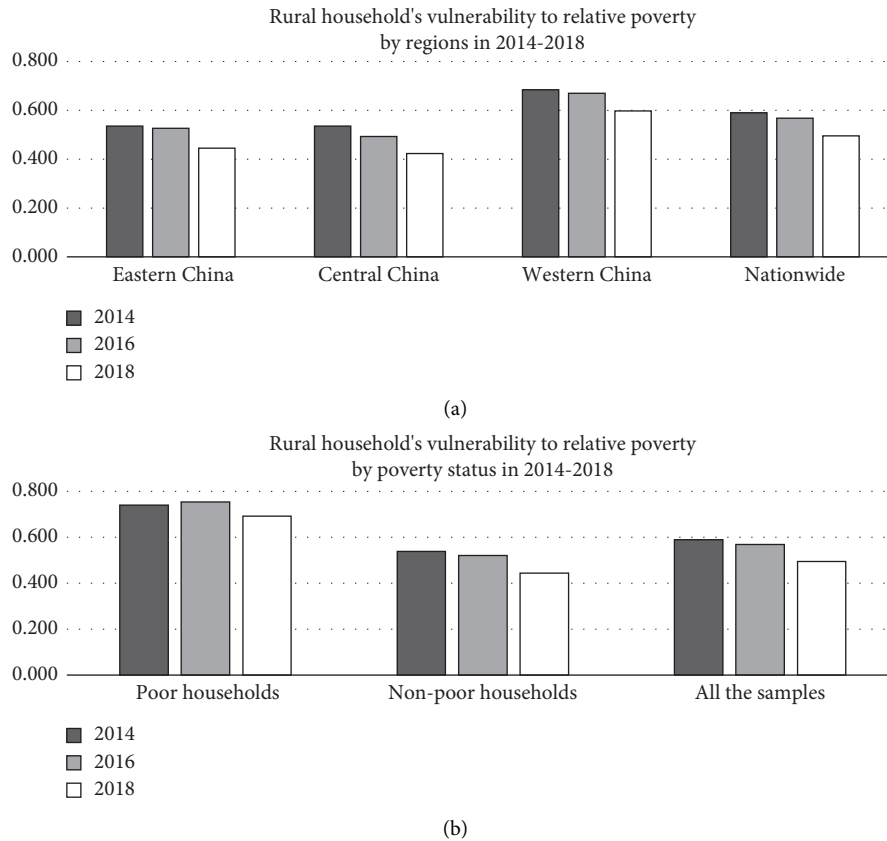


FIGURE 1: Stylized facts of rural household's vulnerability to relative poverty during 2014–2018.

Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi, and Hainan. The central region includes Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan. Western China includes Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, and Chongqing) with a higher level of economic development is associated with lower vulnerability to poverty. The western region with a lower level of economic development is associated with higher vulnerability to poverty. It indicates that the vulnerability to relative poverty has regional heterogeneity. The proportion of vulnerable rural households in central and eastern regions is significantly lower than that in the western region, which is consistent with the fact that most poor rural households in China come from the western region. Vulnerability to relative poverty is both highly correlated with relative poverty, and there are differences between them. Figure 1(b) shows that the vulnerability to relative poverty has poverty status heterogeneity. Under the relative poverty standard, the proportion of households vulnerable to relative poverty in households that are in relative poverty status is higher than that in households that are not in relative poverty status. Due to their own limitations, these poor households are still highly likely to be unable to escape from relative poverty in the future and continue to live in poverty. Rural households that in relative poverty are more likely to fall into relative poverty in the future.

Table 1 shows the relationship between vulnerability to relative poverty and relative poverty. Households in relative poverty and households that are vulnerable to relative poverty cross each other. There are both households that are vulnerable to relative poverty and households that are not vulnerable to relative poverty in households in relative poverty. In other words, rural households currently in relative poverty are not always vulnerable to relative poverty in the future. And rural households currently not in relative poverty are not always nonvulnerable to relative poverty in the future. Rural households are still vulnerable to relative poverty. It means that they have a more than 50% probability of trapping in the relative poverty in the future.

4. Results

4.1. Baseline Regression Results. First, we use the two-way fixed-effects model to analyze the impact of human capital on rural households' vulnerability to relative poverty. The results are shown in the first column of Table 2. On the whole, labor force migration, health, work experience, and education all have a significant negative impact on vulnerability to relative poverty. Among them, labor force migration has the greatest negative impact on vulnerability to relative poverty. The proportion of the labor force migrating to cities increases by 1%, and vulnerability to relative poverty decreases by 29.4%. Rural households' labor force

TABLE 1: Summary statistics.

Variables	Definitions	Mean	Sd
Vulnerability	Vulnerability to relative poverty	0.554	0.288
HC index	Human capital index	0.400	0.243
Migration	Proportion of labor force migrating to the city for work	0.366	0.383
Health	Average health levels of the labor force	2.973	1.016
Working experience	Average years of working in the labor force	29.32	9.391
Education	Year of education of the labor force	6.266	3.367
Social network	Gift expenditure (yuan) of a household per year, taking the logarithm in regression model	7.055	2.377
Social status	Average self-rated social status of adult respondents in a household	3.042	0.806
Social trust	Average self-rated social trust of adult respondents in a household	1.747	1.475
Dependency rate	Proportion of children under 14 and elders over 65 in a household	0.0850	0.159
Age	Age of head of a household	49.65	11.15
Age2	Age square of the head of a household	2,590	1,096
Marriage	Marriage status of head of a household (married = 1)	0.906	0.291
Gender	Gender of head of a household (male = 1)	0.568	0.495
Water	Household has clean water such as tap water (yes = 1)	0.578	0.494
Cook	Household has clean fuel such as gas (yes = 1)	0.464	0.499
Land	Household has land (yes = 1)	0.941	0.235
Financial asset	Household has a land financial asset (yes = 1)	0.00500	0.0730
House	Household has independent property rights to housing (yes = 1)	0.938	0.241
Car	Household has a car (yes = 1)	0.164	0.370
Minorities area	Village the household lives in is a minorities area (yes = 1)	0.141	0.348
Mining area	Village the household lives in is a mining area (yes = 1)	0.0630	0.244
Polluting enterprise	There is a polluting enterprise in the village the household lives in (yes = 1)	0.144	0.352
Distance to county	Nearest distance from the village the household (yes = 1) lives in the county to which the village belongs (li)	54.40	42.19

TABLE 2: The impact of human capital on vulnerability to relative poverty.

	Panel	QR_10	QR_25	QR_50	QR_75	QR_90
Mig	-0.294*** (0.004)	-0.306*** (0.018)	-0.303*** (0.014)	-0.294*** (0.015)	-0.285*** (0.029)	-0.282*** (0.035)
Health	-0.025*** (0.002)	-0.025*** (0.007)	-0.025*** (0.005)	-0.025*** (0.006)	-0.026** (0.011)	-0.026** (0.013)
Workexp	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
Edu	-0.029*** (0.001)	-0.029*** (0.004)	-0.029*** (0.003)	-0.029*** (0.003)	-0.028*** (0.006)	-0.028*** (0.007)
Observations	11,471	11,471	11,471	11,471	11,471	11,471
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Note. Numbers in the parentheses represent robust standard error. Significance level: * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

migrating to the city to work can help them get higher salaries. It is helpful to reduce vulnerability to relative poverty. Vulnerability to relative poverty decreases by 2.9% when the years of education increase by 1 year. Vulnerability to relative poverty decreases by 2.5% when health level increases by 1 unit. Working experience has little impact on vulnerability to relative poverty decreases. Vulnerability to relative poverty decreases by 0.1% when working experience increases by 1 year.

Second, we use the panel quantile model to analyze the complete situation of the impact of human capital on vulnerability to relative poverty. According to most related studies, we select five fractiles of 0.1, 0.25, 0.5, 0.75, and 0.9 for panel quantile regression. The regression results are

shown in columns 2–5 of Table 2, giving a complete situation of the impact of human capital on vulnerability to relative poverty. First, from the 10th to the 90th fractile, labor force migration, education, and health all have significant negative impacts on vulnerability to relative poverty. Moreover, labor force migration has the greatest negative impact on vulnerability to relative poverty among them from the 10th to the 90th fractile. The negative impact of labor force migration gradually decreases with the increase of fractile. Labor force migration has the greatest impact on the vulnerability to relative poverty of rural households, which has a low vulnerability to relative poverty. Vulnerability to relative poverty of rural household that has a low vulnerability to relative poverty decreases by 30.6% when the proportion of

TABLE 3: Impact of human capital on vulnerability to relative poverty by regions.

	PanelL	QR_10	QR_25	QR_50	QR_75	QR_90
<i>Panel A: east region</i>						
Mig	-0.316*** (0.007)	-0.326*** (0.029)	-0.323*** (0.023)	-0.316*** (0.023)	-0.309*** (0.041)	-0.306*** (0.049)
Health	-0.026*** (0.003)	-0.024** (0.012)	-0.025*** (0.009)	-0.026*** (0.009)	-0.028* (0.017)	-0.029 (0.020)
Workexp	-0.001** (0.000)	-0.001** (0.000)	-0.001** (0.000)	-0.001** (0.000)	-0.001 (0.003)	-0.001 (0.003)
Edu	-0.027*** (0.002)	-0.027*** (0.006)	-0.027*** (0.005)	-0.027*** (0.005)	-0.027*** (0.009)	-0.027** (0.011)
Observations	3,956	3,956	3,956	3,956	3,956	3,956
<i>Panel B: central region</i>						
Mig	-0.301*** (0.007)	-0.312*** (0.069)	-0.309*** (0.056)	-0.302*** (0.040)	-0.293*** (0.057)	-0.290*** (0.069)
Health	-0.029*** (0.003)	0.030 (0.027)	0.030 (0.022)	-0.029* (0.015)	0.029 (0.022)	0.028 (0.027)
Workexp	-0.001 (0.000)	-0.001 (0.004)	-0.001 (0.004)	-0.001 (0.002)	-0.001 (0.004)	-0.001 (0.004)
Edu	-0.031*** (0.002)	-0.031** (0.015)	-0.031*** (0.012)	-0.031*** (0.008)	-0.030** (0.012)	-0.030** (0.015)
Observations	3,336	3,336	3,336	3,336	3,336	3,336
<i>Panel C: west region</i>						
Mig	-0.265*** (0.007)	-0.279*** (0.030)	-0.275*** (0.025)	-0.265*** (0.014)	-0.254*** (0.014)	-0.250*** (0.018)
Health	-0.021*** (0.002)	-0.023** (0.010)	-0.022*** (0.008)	-0.021*** (0.005)	-0.020*** (0.005)	-0.020*** (0.006)
Workexp	-0.001* (0.000)	-0.001* (0.000)	-0.001* (0.000)	-0.001* (0.000)	-0.001* (0.000)	-0.001* (0.000)
Edu	-0.028*** (0.001)	-0.030*** (0.005)	-0.029*** (0.004)	-0.028*** (0.002)	-0.027*** (0.003)	-0.027*** (0.003)
Observations	4,179	4,179	4,179	4,179	4,179	4,179
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Note. Numbers in the parentheses represent robust standard error. Significance level: * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$. PANEL means the two-way fixed effected model. QR means the panel quantile regression model. QR_10 means the regression results of panel quantile regression model in 10 percentile. QR_25 means the regression results of panel quantile regression model in 25 percentile. QR_50 means the regression results of panel quantile regression model in 50 percentile. QR_75 means the regression results of panel quantile regression model in 75 percentile. QR_90 means the regression results of panel quantile regression model in 90 percentile.

the labor force migrating to cities increases by 1%. At different fractiles of vulnerability to relative poverty, the impact of education and health on vulnerability to relative poverty fluctuates little, and coefficients are basically stable around the estimated value of the two-way fixed-effect model.

4.2. Heterogeneity Analysis

4.2.1. *The Impact of Human Capital on Vulnerability to Relative Poverty by Regions.* The two-way fixed-effects model regression results are shown in column 1 of Table 3. No matter in the east, central, or west region, labor force migration, health, education, and work experience all significantly reduce vulnerability to relative poverty. Only in east and west regions has working experience a significant negative effect on vulnerability to relative poverty. But the effect is small. Labor force migration has the biggest negative effect on vulnerability to relative poverty in the east region.

When the proportion of labor force migration increases by 1%, vulnerability to relative poverty decreases by 31.6%. Health has the greatest negative impact on vulnerability to relative poverty in the central region. When health level increases by 1%, vulnerability to relative poverty decreases by 2.9%. Education has the greatest negative impact on vulnerability to relative poverty in the central region. When years of education increase by 1 year, vulnerability to relative poverty decreases by 3.1%.

Panel quantile regression results are shown in columns 2–6 in Table 3, which provide a complete situation of the impact of human capital on vulnerability to relative poverty in different regions. From the 10th to the 90th fractile, labor force migration has a significant negative impact on vulnerability to relative poverty in eastern, central, and western regions. The impact of labor force migration gradually decreases with the increase of fractile. Labor force migration has the biggest negative impact on rural households that has a low vulnerability to relative poverty in eastern, central, and

TABLE 4: Impact of human capital on vulnerability to relative poverty by poverty status.

	Panel	QR_10	QR_25	QR_50	QR_75	QR_90
<i>Panel A: poor households</i>						
Mig	-0.211*** (0.013)	-0.220*** (0.025)	-0.219*** (0.022)	-0.211*** (0.013)	-0.203*** (0.014)	-0.202*** (0.017)
Health	-0.019*** (0.004)	-0.018*** (0.007)	-0.018*** (0.006)	-0.019*** (0.003)	-0.020*** (0.004)	-0.020*** (0.005)
Workexp	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)
Edu	-0.020*** (0.002)	-0.021*** (0.004)	-0.021*** (0.003)	-0.020*** (0.002)	-0.020*** (0.002)	-0.019*** (0.003)
Observations	2,518	2,518	2,518	2,518	2,518	2,518
<i>Panel B: nonpoor households</i>						
Mig	-0.310*** (0.005)	-0.315*** (0.053)	-0.314*** (0.045)	-0.310*** (0.024)	-0.306*** (0.015)	-0.305*** (0.021)
Health	-0.027*** (0.002)	-0.026 (0.020)	-0.027 (0.017)	-0.027*** (0.009)	-0.028*** (0.006)	-0.028*** (0.008)
Workexp	-0.001** (0.000)	-0.001*** (0.000)	-0.001** (0.000)	-0.001 (0.002)	-0.001 (0.001)	-0.001 (0.001)
Edu	-0.030*** (0.001)	-0.031*** (0.011)	-0.031*** (0.009)	-0.030*** (0.005)	-0.029*** (0.003)	-0.029*** (0.004)
Observations	8,953	8,953	8,953	8,953	8,953	8,953
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Note. Numbers in the parentheses represent robust standard error. Significance level: * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$. PANEL means the two-way fixed effected model. QR means the panel quantile regression model. QR_10 means the regression results of panel quantile regression model in 10 percentile. QR_25 means the regression results of panel quantile regression model in 25 percentile. QR_50 means the regression results of panel quantile regression model in 50 percentile. QR_75 means the regression results of panel quantile regression model in 75 percentile. QR_90 means the regression results of panel quantile regression model in 90 percentile.

western regions. From the 10th to the 90th fractile, the negative impact of education in eastern, central, and western regions fluctuates little, and the regression coefficients are stable around the estimated value of the two-way fixed-effects model. The impact of health on vulnerability to relative poverty in eastern and western regions is complete at different fractiles. In the eastern region, health has a significant negative impact from the 10th to the 75th fractile. The negative impact increases slowly with the increase of fractile. In the western region, health has a significant negative impact from the 10th to the 90th fractile, and the negative impact decreases slowly with the increase of fractile. In the central region, only has health level a negative impact in the 50th fractile.

4.2.2. The Impact of Human Capital on Vulnerability to Relative Poverty by Poverty Status. The two-way fixed-effects model regression results are shown in column 1 of Table 4. No matter rural household is in poor status or nonpoor status, labor force migration, health, and education all significantly reduce vulnerability to relative poverty. Only has work experience a negative effect on vulnerability to relative poverty of nonpoor households. But the effect is little. Labor force migration, health, and education have a greater effect on the vulnerability to relative poverty of nonpoor households than poor households. Vulnerability to relative poverty of poor households decreases by 21.1%, and

that of nonpoor households decreases by 31.0% when the proportion of the labor force migrating to cities increases by 1%. Vulnerability to relative poverty of poor households decreases by 1.9%, and that of nonpoor households decreases by 2.7% when health level increases by 1 unit. Vulnerability to relative poverty of poor households decreases by 2.0%, and that of nonpoor households decreases by 3.0% when years of education increase by 1 year.

Panel quantile regression results are shown in columns 2–6 in Table 4, which provide a complete situation of the impact of human capital on vulnerability to relative poverty of households in different poverty statuses. From the 10th to the 90th fractile, the negative impact of labor force migration on vulnerability to relative poverty of poor farmers decreased gradually from -0.220 to -0.202 with the increase of fractile. But, from the 10th to the 75th fractile, the negative impact of labor force migration on vulnerability to relative poverty of nonpoor farmers decreased gradually from -0.315 to -0.306 with the increase of fractile. From the 75th to the 90th fractile, the negative impact increases from -0.306 to -0.315 . For poor households, the negative impact on health increases slowly with the increase of fractile. For nonpoor households, only has health a significant negative impact from the 50th fractile to the 75th fractile. The negative influence of education fluctuates little both on poor and nonpoor households. The regression coefficients are stable around the estimated value of the two-way fixed-effects model.

TABLE 5: Endogeneity analysis.

	Fe	IV-FE	IV exogenesis test	
HCindex	-0.521*** (0.008)	-0.460*** (0.023)		-0.527*** (0.008)
Village_HCindex			-0.442*** (0.029)	-0.064*** (0.023)
Observations	11,471	11,471	11,471	11,471
Controls	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Davidson-MacKinnon <i>p</i> value		0.001***		
First stage F-stat		706.34		
First stage <i>T</i> value		26.58***		

Note. Numbers in the parentheses represent robust standard error. Significance level: * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

4.3. Endogeneity Analysis. We use an instrumental variable to solve potential endogeneity problems in the regression model. Based on the ideas of Rozelle [33], we adopt the human capital index of the village where rural household lives as an instrument variable. The human capital of villages is inevitably related to the human capital of rural households living in, and it does not directly affect the vulnerability to relative poverty of individual rural households. Theoretically speaking, the establishment of this logic requires that instrument variables meet the two conditions of relevance and exclusivity. Table 5 shows the 2SLS estimation result. The Davidson-MacKinnon endogeneity test result rejects the null hypothesis that there is no endogeneity problem in the formula (6) at the 1% level of significance, indicating that rural households' human capital index is endogenous. In the first stage regression, the Kleibergen-Paap rk Wald F-statistic is 706.34, which is far beyond the critical value of 16.38 at the 10% level of error, indicating that there is no weak instrument variable problem. In addition, the *t* value of the instrument variable is 26.58, passing the 1% level of a significance test, indicating that there is a strong correlation between the rural household's human capital index and the instrument variable. Column 2 shows the estimated result in the second stage regression. The coefficient of the human capital index is -0.460 at the 1% level of significance. Vulnerability to relative poverty decreases by 46.0% when the human capital of rural household index increases by one unit. Compared with the result in column 1, the influence direction and significance of the human capital index are basically consistent with an estimation of the two-way fixed-effects model. The estimated result of 2SLS indicates that the impact of human capital on vulnerability to relative poverty is overestimated due to the existence of endogenous problems.

The assumption of the exclusivity of the instrument variable cannot be tested directly because the instrument variable is just identified. Referring to the approach of Ashraf [34], we use an alternative test as follows. We use the instrument variable to replace the key explanatory variable and regress. The result is shown in column 3. Then we put the human capital index and the instrument variable in the model at the same time and regress. The result is shown in column 4. In column 3, where only is instrument variable controlled, the

TABLE 6: Moderating effect of social capital.

	Panel
Household_HCindex*	-0.487*** (0.061)
Household_SCindex	
Household_HCindex	-0.378*** (0.020)
Household_SCindex	-0.164*** (0.025)
Controls	Yes
Household FE	Yes
Year FE	Yes

Note. Numbers in the parentheses represent robust standard error. Significance level: * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

TABLE 7: Robustness check.

	Relative poverty line, 40% of median income		Relative poverty line, 60% of median income	
HCindex	-0.529*** (0.007)		-0.449*** (0.008)	
Mig	-0.297*** (0.004)		-0.255*** (0.005)	
Health	-0.024*** (0.002)		-0.023*** (0.002)	
Workexp	-0.001* (0.000)		-0.001*** (0.000)	
Edu	-0.029*** (0.001)		-0.025*** (0.001)	
Observations	11,471	11,471	11,471	11,471
Controls	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

village human capital index of the village significantly reduces vulnerability to relative poverty at the 1% level of significance. In column 4, where both the human capital index of household and the instrument variable are controlled, human capital significantly reduces vulnerability to relative poverty *t* the 1% level of significance. The impact of the human capital of households on vulnerability to relative poverty decreases from -0.442 to -0.064. This auxiliary test supports the exclusivity hypothesis of the instrument variable in this paper

from one side: human capital of village reduces vulnerability to relative poverty of household by increasing human capital of household, but it does not directly affect vulnerability to relative poverty of household.

4.4. Moderating Effect of Social Capital. Some scholars point out that whether human capital can play a role in poverty depends on its social environment. Social capital such as social networks, social trust, and social status can play a certain role in the development of farmers. We also adopt the entropy method to calculate the social capital index of rural households. We put both the human capital index and the social capital index and their interaction terms into the estimation model to explore the moderating effect of social capital on the relationship between human capital and vulnerability to relative poverty. The sign of the interaction coefficient and its significance is worth paying attention to. The regression results are shown in Table 6. The results show that the interaction coefficient is negative at the 1% level of significance, indicating that social capital strengthens the negative effect of human capital on vulnerability to relative poverty.

4.5. Robustness. We use strategies to test robustness as follows. The relative poverty line in the baseline regression is 50% of median income. We changed the relative poverty judgment standard and adopted 40% and 60% of the median income as the relative poverty line respectively. The regression results are shown in Table 7. The change in relative poverty standard does not change the conclusion of this paper. The empirical results in baseline regression are robust.

5. Conclusions

Drawing on three-wave panel data from China Family Panel Studies (CFPS) of 2014, 2016, and 2018, we measure rural households' vulnerability to relative poverty by using the three-stage feasible generalized least squares (FGLS) model. Then we analyze the impact of human capital on rural households' vulnerability to relative poverty by using the two-way fixed-effects model and panel quantile model. The descriptive results show that rural households' vulnerability to relative poverty in China is descending over time. Rural households in the western region are most vulnerable to relative poverty.

The empirical results indicate that labor force migration, health level, years of education, and work experience have a significant negative impact on vulnerability to relative poverty. Labor force migration has the greatest impact on farmers' vulnerability to relative poverty. The influence of different dimensions of human capital on vulnerability to relative poverty varies. With the increase of fractile, the impact of labor force migration gradually decreases, but the impact of years of education and health level fluctuated little. The results of heterogeneity analysis show that no matter in the east, central, or west region, labor force migration, health level, years of education, and

work experience all significantly reduce vulnerability to relative poverty. Only in east and west regions has working experience a significant negative effect on vulnerability to relative poverty. But the effect is small. Labor force migration has the biggest negative effect on vulnerability to relative poverty in the east region. Both health and years of education have the greatest negative impact on vulnerability to relative poverty in the central region. Regardless of whether the rural household is in poor status or nonpoor status, labor force migration, health level, and years of education all significantly reduce vulnerability to relative poverty. Only has work experience a negative effect on vulnerability to relative poverty of nonpoor households. But the effect is little. Labor force migration, health level, and years of education have a greater effect on the vulnerability to relative poverty of nonpoor households than poor households.

Conclusions above have policy implications as follows. First, although China has achieved initial success in poverty alleviation, major changes have taken place in the structure of social poverty, with people in relatively poverty status becoming the main group. Under the current antipoverty background, China's poverty alleviation work will change from eliminating absolute poverty to alleviating relative poverty. Most rural households' vulnerability to relative poverty are still very high. Therefore, the government should consider the vulnerability to relative poverty when assess rural household's poverty.

The government should continue to promote policies such as industrial targeted poverty alleviation and transfer employment targeted poverty alleviation to provide more job opportunities for rural households. The government should also enhance the human capital accumulation of rural households. For example, more skills training courses should be held to improve the vocational skills of farmers. The government should guide farmers form their own awareness of poverty alleviation. The government will continue to improve the new rural cooperative medical care insurance and expand the coverage of insurance to ensure the health of farmers.

Data Availability

The CFPS data used to support the findings of this study have been deposited in <http://www.issp.pku.edu.cn/cfps>.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Authors' Contributions

J.S. contributed to the following aspects: conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, visualization, and supervision. G.R. contributed to the following aspects: validation, writing—original draft preparation, writing—review and editing, and project administration. All

authors have read and agreed to the final version of the manuscript.

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