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Spatial segregation and human capital of impoverished areas in China: Implications for livelihood resilience building

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Abstract

Improving people's livelihood resilience against risks and challenges plays an important role in consolidating the achievements of poverty reduction. The paper uses 64 poverty-stricken counties in China's Sichuan province as the study area and explores the link between spatial segregation and human capital. The results show that the proximity (spatial segregation) is significantly and negatively associated with people's educational attainment and their acquisition of non-farming employment. Residents in villages which are distant from the county center tend to obtain less educational opportunities and are less likely to engage in non-farming jobs than those who are close to the county center. The mediating effect analysis indicates that remoteness mainly reduces the propensity of getting non-farming jobs by reducing the human capital of rural residents. Further analysis shows that the association between proximity, human capital and the probability of acquiring non-farming work is higher in areas with lower economic level and less developed transportation infrastructure. Policy implications for improving people's livelihood resilience in impoverished areas are proposed in the paper.

Keywords: spatial segregation, human capital, rural poverty, livelihood resilience, China.
JEL classification: E24, O18, R12.

1. Introduction

Human society has achieved great progress in poverty reduction during the past decades though various challenges still exist which may set back this

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cause. The World Bank statistics show a reduction of 1.22 billion people out of poverty (below $1.90 a day at 2011 Purchasing Power Parity) in the period 1990–2017.[1] Accompanying this progress, the world's poverty gravity center has also moved from Asia to Africa and will move further to the African continent in the coming decades (Li et al., 2021). Today, more than 700 million people still live in extreme poverty across the world, fighting for the most basic needs such as health, education, sanitation, etc. However, natural disasters, conflicts, economic recessions and pandemics are jointly undermining the progress of poverty reduction in the world. For instance, the United Nations University World Institute for Development Economics Research (2020) estimates that the COVID-19 pandemic will have sent around 420–580 million people back into poverty, reversing decades of poverty reduction across the world.

Being the most populous country in the world, China has been fighting poverty, in tandem with the state promoting its long-term economic growth, since 1949 when P. R. China was founded. In this process, a series of measures were taken towards poverty reduction. In particular, China initiated the targeted poverty alleviation strategy in late 2013 and identified 70.17 million rural impoverished inhabitants who are living below the national poverty line (RMB 2,300 per capita annual net income, equivalent to $314). By the end of 2020, all this impoverished population shook off poverty. In the meantime, a total of 832 nationally designated poor counties and 128,000 impoverished villages rose up from poverty. The complete eradication of extreme poverty in China is 10 years ahead of the schedule to accomplish the UN's no-poverty goal by 2030. This campaign has led to dramatic changes in the lives of the impoverished and laid the foundations for overall development of poverty-stricken areas in the future.

Decades of research have illustrated the multidimensional fact of poverty which closely relates to people's status in terms of material deprivation, social isolation, exclusion and powerlessness, and physical and psychological ill-being (Sen, 1999; Tsui, 2002; Ravallion, 2011; Xiao and Wu, 2021). Various efforts have been introduced to end poverty such as improving infrastructure, developing local economy and providing public services like education and medical insurance. The ultimate purpose of these efforts to end poverty is to improve the resilience of the impoverished body against unexpected shocks and create a stable status with increased capacity to avoid returning to poverty. However, it should be noted that these efforts by governments and other bodies merely serve as an external force in the poverty-stricken areas. As Wood (2008) indicated, local people's desire for better livelihood and their hard work, frugality and self-reliance play a dominant role in achieving poverty reduction goals.

In early 2021, China set a five-year transitional period (2021–2025) to consolidate and expand the achievements of poverty reduction, and raise the overall effect of development in areas that have cast off poverty. Improving poor households' livelihood resilience against challenges and shocks has been emphasized to reduce the risks of reverting to poverty. Generally, the vulnerable groups are those in China's west and southwest mountainous areas which are characterized by less developed economy, backward infrastructure, inadequate public services, and social and economic underdevelopment. Particularly,

[1] https://www.worldbank.org/en/understanding-poverty

the spatial location of those mountainous poor areas has segregated people from reaching the outside world. Our concern lies in the impact of spatial segregation on people's access to education, and how human capital of the poor influences their access to jobs that would boost their livelihood resilience and provide a stable route out of poverty.

The paper takes Sichuan province as the study area, a region in the southwest of China that has profound poverty. There were 6.25 million poor people in Sichuan province by the end of 2013, accounting for 7% of the total poor people of China. The poverty incidence of this province was 9.6% which was higher than in many other places in China. The aim of the paper is to investigate the logic between spatial segregation and human capital accumulation as well as livelihood resilience of the poor. The structure of the paper is as follows. Section 2 introduces China's targeted poverty alleviation and the relationship between spatial segregation and human capital accumulation as well as people's livelihood resilience. In Section 3, the paper explains in detail the research area, methodology and data sources. Section 4 presents the research findings which are followed by the discussion and conclusion of the paper.

2. China's targeted poverty alleviation strategy

China has a total population of 1.4 billion people who are spatially distributed in a vast territory of diversified socioeconomic and geographical conditions. Besides its weak socioeconomic foundations and uneven territorial development, China has long been bedeviled by poverty. China's fight against it entered a critical stage in 2012 as the nation endeavored to accomplish its First Centenary Goal to build a moderately prosperous society in all respects by 2020. No single poor area or single poor person should be left behind in achieving this goal — that has been particularly emphasized by the Chinese government. Then, the targeted poverty alleviation strategy was initiated and implemented which highlights the importance of correct poverty identification, appropriate projects arrangement and accurate implementation effect to ensure that the assistance reaches poverty-stricken villages and households (Li et al., 2016). Then, 14 contiguous poverty-stricken regions, 832 nationally designated poor counties, 128,000 impoverished villages and 70.17 million rural impoverished people were identified in the central and western China. It is noteworthy that the majority of China's poor population is residing in mountainous and hilly areas which are spatially distant from city centers. Spatial segregation has to a large extent blocked local people's access to qualitative education and development opportunities.

The contribution of China's targeted poverty alleviation to rural development is multifaceted (Fig. 1). According to our understanding, among the most remarkable achievements are the improvements in local infrastructure that have intensified the links between poor areas and the outside world. By the end of 2020, China had newly built and reconstructed 1.1 million kilometers of rural roads and 35,000 kilometers of railways in impoverished areas. All the villages, townships and towns in poverty-stricken areas became accessible by paved roads and provided with bus and mail routes while fiber and 4G internet reached 98% of poor villages (State Council of China, 2021). Poverty-stricken areas have

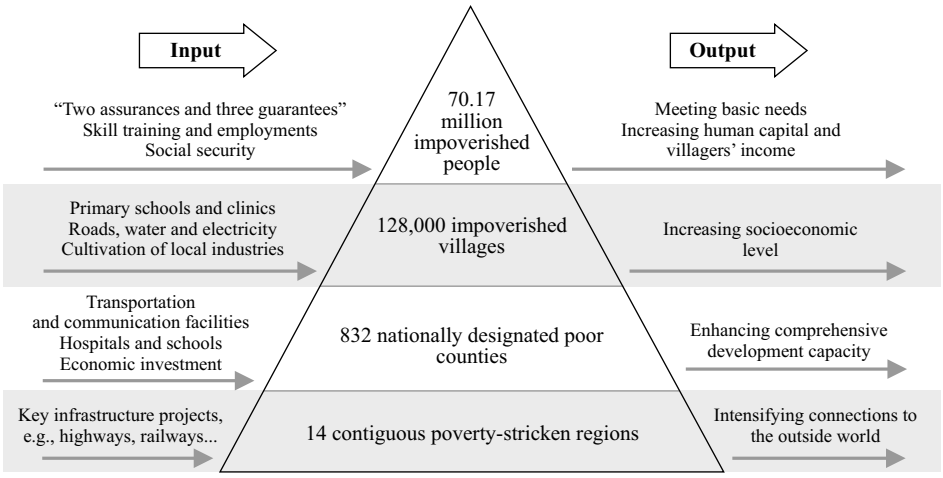

Fig. 1. The hierarchy of China's targeted poverty alleviation.

Source: Compiled by the authors.

seen notable improvements in their economy of facilitated flows of personnel, logistics, knowledge, and information with the outside world.

Eradicating poverty through education (including professional training) has been highly emphasized in China with the aim of improving poor people's human capital and their livelihood resilience in the long run. The Chinese governments have invested much in education, and people's health care in the impoverished areas. As a result, 108,000 primary schools have been renovated since 2013 to strengthen the provision of compulsory education in poor areas, and ensure that all school-age rural children receive kindergarten and elementary education within their own villages. More than 8 million poor households were offered professional education and training. All these efforts and input have helped the poor to obtain greater knowledge and skills, and enabled them to get better paid jobs through improved human capital. Statistics show that the number of poor people who get employment or start their own business increased from 12.27 million in 2015 to 32.43 million in 2020. This has greatly contributed to the increase of impoverished people's income. The per capita disposable income of the rural poor increased from RMB 6,079 (equivalent $831) in 2013 to RMB 12,588 (equivalent $1,721) in 2020, up by 11.6% per annum on average.

3. Theoretical background: spatial segregation, human capital and livelihood resilience

As Bardhan and Udry (1999) noted, human society has experienced spatial transformation from dispersed rural to more concentrated urban and industrial economy. Theoretically, falling transportation costs have accelerated the process of societal transformation which saw labor mobility from the rural based agrarian sector to the urban based industrial one (Nerlove and Sadka, 1991; Xiao and Zhao, 2018, 2020). However, the vast peripheral rural areas, located in places that were far away from the impact of big cities, have declined owing

to the increased capital and knowledge intensity of those natural resource-based industries (Westlund, 2018). Moreover, the spatial segregation of peripheral rural regions has also blocked rural people's equal access to investment, education, medical care, and development opportunities, etc. compared to citizens in urban areas. This has consequently resulted in the weakened capacity of rural dwellers to obtain a better livelihood. Such results can be exacerbated further in today's knowledge economy in which economic activities of human society mainly concentrate in big city areas and demand more in terms of laborers' skills and innovation (Westlund and Kobayashi, 2013).

The concept of resilience has gained people's attention in recent decades as human society is facing climatic, economic, and social changes and unforeseen challenges which have caused huge losses in terms of human lives and prosperity (Carpenter et al., 2001; Folke et al., 2002; Berkes et al., 2008; Nelson et al., 2007; Cabell and Oelofse, 2012; Li et al., 2019). As Tanner et al. (2015) illustrated, resilience characterizes human society's ability to deal with changes and unexpected risks and challenges. The poor, especially those in rural areas, are mostly affected by economic shocks, climate-change induced disasters and environmental degradation, etc. In most circumstances, poor people often lack the ability to cope with challenges (FAO, 2021). As a result, the rural poor's livelihood resilience against shocks and challenges degrades owing to their limited access to capital assets (financial, physical, natural, human, and social) which are important for generating income, means of livelihoods and other benefits (Rakodi, 1999; Babulo et al., 2008).

Generally, resilience indicates the capacity of a system to absorb stresses and disturbances while maintaining or improving essential properties and functions (Li, 2023). Livelihood resilience is characterized by households' assets and strategies to get better prepared to cope with shocks and adapt to changing conditions through self-organization and learning (Marschke and Berkes, 2006; Speranza et al., 2014). The resilience theory further highlights the transformative capacity of a system to create a completed new development trajectory through self-learning and entrepreneurial adaptation (Folke et al., 2010; Scott, 2013). In this sense, human capital, which represents the skills, knowledge and good health, plays an important role in contributing to households' resilience. This is realized through enabling people to perform diversified livelihood activities and achieve their livelihood objectives (Becker, 1993). Moving into resilient and better-off livelihood usually requires increasing human capital in the forms of skills and education. However, rural households in poor areas tend to rely on natural capital and ecosystem services for maintaining their livelihood and well-being more than most other groups. In the meantime, the impoverished population also has to contend with weaker governmental investments in their human capital (United Nations, 2021).

4. Research methodology and data source

4.1. Research area

This study targets all the poor counties in Sichuan province which is located in the Sichuan Basin in Southwest China (Fig. 2). Sichuan province has 18 prefecture-

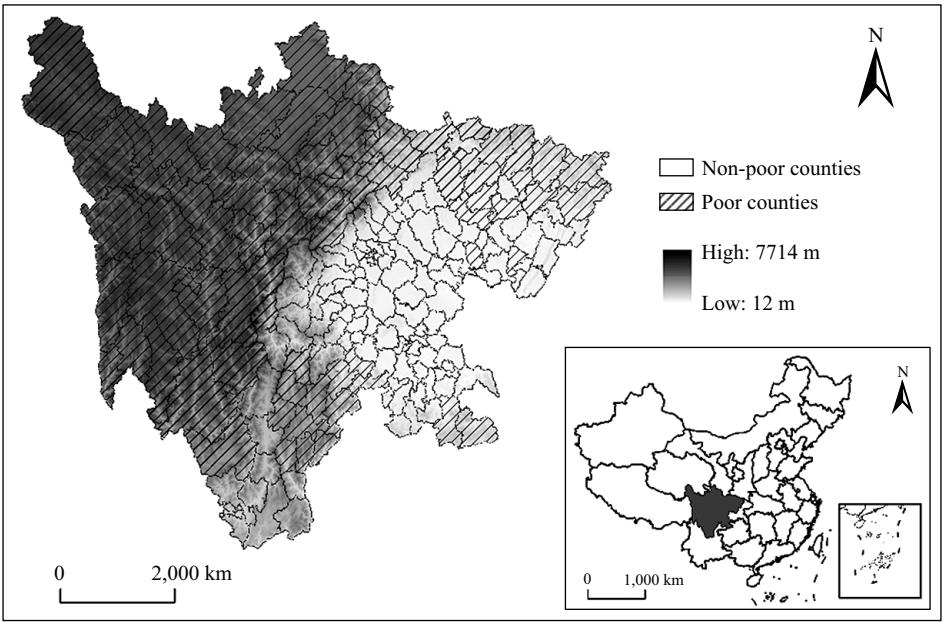

Fig. 2. The location and poor counties of Sichuan Province.

Source: Compiled by the authors.

level cities[2] and 183 county-level divisions under its jurisdiction. The total land area of Sichuan province is about 486,000 sq. km accounting for 5.1% of China's total land area. The western Sichuan province is covered by plateaus and mountains, with altitudes mostly above 3000 m, and its eastern part is composed by basins and hills, with altitudes mostly between 500 to 2000 m. In 2020, Sichuan province had a permanent population of 83.67 million and the per capita GDP was RMB 58,000 (equivalent $7,929). Sichuan province, together with other southwest provinces, has always been the focus of China's poverty alleviation efforts. In 2013, when China implemented its targeted poverty alleviation strategy, there were 66 national poor counties in Sichuan province, accounting for 36% of its total counties. In the meantime, a total amount of 11,501 poor villages and 6.25 million rural poor people were identified with the poverty incidence of 9.6% in Sichuan province. The rural per capita net income of Sichuan province was only RMB 2,763 (equivalent $377) in 2013, which was much less than the national level (RMB 8,896, equivalent $1,216). As Fig. 2 shows, most of the poor counties are located in the western and southern parts of Sichuan province and these places which are of high altitude are mountainous areas.

4.2. Empirical strategy

In this study, we proceed from the fact that people's educational attainment is the key way to human capital accumulation which further influences their occupation acquisitions and ways of livelihood. The more education an individual has obtained, the more stable and better-off livelihood he can attain. To examine

[2] A prefecture-level city directly subordinates to the province, and is not administratively associated with other prefecture cities.

the effect of spatial segregation of villages on residents' educational attainment and occupational acquisitions, we estimate the following equation:

$$Dept_{ivc} = \alpha + \beta_1 Dist\_county_{vc} + \beta_2 Dist\_prefecture_{vc} + \theta X_{ivc} + \\ + county_c + \varepsilon_{ivc}, \quad (1)$$

where the subscript *ivc* indicates that the variable is for an individual *i* from village *v* in county *c*. The dependent variable $Dept_{ivc}$ represents two outcomes. The first outcome is Edu_{ivc}, the educational attainment of individual *i*, including the number of educational years and whether the individual has completed junior high school education or senior high school education. The second outcome is a dummy variable $Occup_{ivc}$ that is equal to 1 if individual *i* was engaging in a non-farming job in 2015. The key explanatory variables $Dist\_county_{vc}$ and $Dist\_prefecture_{vc}$ are the logarithmic distance from village *v* to the center of its county and prefecture, respectively. X_{ivc} represents a group of individual characteristics affecting educational attainments, such as gender, age, age squared, and a dummy Han for the Han ethnic group. The county fixed effects help remove the effects of county-level characteristics, such as the spatial advantage, social conventions, the average level of educational development, the number of schools, and the teacher-student ratio. Adding the county fixed effect in the regression helps us control all these regional factors.

4.3. Data and descriptive statistics

Due to the availability of data, we select 64 poverty-stricken counties as the study area. Our data includes both individual and county level data. Individual information is extracted from the mini-census conducted by the National Bureau of Statistics of China in 2015 when the country was in the process of promoting the targeted poverty alleviation. The 2015 mini-census collected a wealth of demographic information such as gender, age, educational level, and employment status of 1.55% of China's population. Due to their small population size, some poor counties in Sichuan province were not covered by the 2015 mini-census.

This study aims to explore the association between spatial segregation and educational attainment of rural residents in Sichuan province that includes a large group of impoverished counties. To measure the spatial segregation, we calculate the spatial distance from a village to the center of the county, or prefecture, which is administratively managing the village and county. We only keep rural residents between the age 15 and 60 and exclude individuals who were still in school in 2015. We also exclude villages with less than 20 observations. The GDP of counties is collected from the China Statistical Yearbook (County-level). Some counties are not included in the data due to their small population size. The total amount of the research sample is 13,009 individuals from 653 villages located in 64 impoverished counties in Sichuan province.

Table 1 presents the descriptive statistics of the final sample. On average, rural residents in our sample have eight school years.[3] 56.7% of the individuals have completed junior high school, and 17.9%—senior high school or above.

[3] In China, there are six years of primary school education while 3 years of middle school and 3 years of high school education.

Table 1
Summary statistics.

Variables	*N*	Mean	Std. dev.	Min	Max
Village characteristics					
Ln (Distance to the county center, km)	13,009	2.5927	1.1491	0.0630	4.3786
Ln (Distance to the prefecture center, km)	13,009	4.1795	0.6381	1.9473	6.0910
Educational attainment					
Educational years	13,009	7.7948	3.8313	0	19
Junior high school or above	13,009	0.5666	0.4956	0	1
Senior high school or above	13,009	0.1786	0.3830	0	1
Employment information					
Non-farming job	10,545	0.4677	0.4990	0	1
Individual characteristics					
Male	13,009	0.5125	0.4999	0	1
Han nationality	13,009	0.7144	0.4517	0	1
Age (years)	13,009	38.3405	11.6570	15	60
Age squared	13,009	1605.8710	895.5428	225	3600
County characteristics					
Ln (GDP, RMB)	13,009	13.2251	1.0155	10.9164	14.7946
Highway	13,009	0.5452	0.4980	0	1
Railway	13,009	0.2194	0.4138	0	1

Note: 1/0 means “yes” / “no”. Han nationality 1 — 100%.
Source: Authors calculations.

Approximately 47% of rural residents took a non-farming job in the sample period. About 51.3% of the sample are male, and the average age of individuals is about 38 years. Sichuan province contains a large group of ethnic minorities, so the proportion of Han nationality in the sample (71.4%) is lower than the national average (about 91.5%). Table 1 also reports the summary statistics of GDP at the county level. Traffic maps help us confirm whether a county has access to highways and railways in the sample period, which improves the connectivity of counties to local and national markets. The size and development stage of the economy in a county and the connectivity to large markets may affect the association between spatial segregation, human capital accumulation, and occupational acquisitions.

5. Research results

5.1. Spatial segregation and educational attainment

By estimating Equation (1), Table 2 shows that the distance from a village to the county center is negatively associated with the years of education of residents in the village. Columns (1) and (2) report the estimation results for the full sample after controlling for the county-fixed effects. The estimated coefficient of the village’s distance to the county center is significant and negative at the 1% level. Keeping other things equal, a unit increase in the distance to the county center results in a 0.7146 unit decrease in people’s educational years. This shows that without any controls of demographic characteristics, the farther the village is located from the county center, the less educational years the residents may obtain. In contrast, the estimated coefficient of the village’s distance to the prefecture center is insignificant, indicating that residents’ educational years are not

Table 2
Spatial segregation of villages and educational attainment: educational years.

Variable	Educational years				
	(1)	(2)	(3)	(4)	(5)
Ln (Distance to the county center)	–0.7146*** (0.0859)		–0.6925*** (0.0858)		–0.6912*** (0.0864)
Ln (Distance to the prefecture center)		–0.3422 (0.3084)		–0.2530 (0.2929)	–0.1469 (0.3034)
Male			0.8887*** (0.0514)	0.8516*** (0.0523)	0.8891*** (0.0514)
Han nationality			1.9683*** (0.2775)	2.4024*** (0.2818)	1.9598*** (0.2782)
Age			–0.0181 (0.0185)	–0.0089 (0.0192)	–0.0183 (0.0184)
Age squared			–0.0011*** (0.0002)	–0.0012*** (0.0002)	–0.0011*** (0.0002)
County fixed effects	Y	Y	Y	Y	Y
N	13,009	13,009	13,009	13,009	13,009
R squared	0.2844	0.2482	0.4082	0.3750	0.4083

Note: Robust standard errors are in parentheses, which are clustered at the village level. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: Authors calculations.

associated with the distance from a village to the prefecture center. In China, each county has full coverage of education resources — from primary school to middle school and further to high school. And primary schools are located in each village while middle schools are normally established at a township level. High schools are mainly located in the county center. Rural students will choose to complete their education from primary to high schools within their county administration. Thus, the distance from villages to the county center matters in impacting a student's educational attainments. Columns (3) and (4) show that the estimated coefficients are similar when controlling for individual characteristics. Column (5) reports that the estimated coefficient of a village's distance to the county center is significant and negative at the 1% level when controlling for individual characteristics. Keeping other things equal, a unit increase in the distance to the county center results in a 0.6912 unit decrease in people's educational years. However, the estimated coefficient of the distance from the village to the prefecture center is insignificant. The results show that educational years of residents in a village are significantly and negatively correlated with the distance from the village to the county center but not with the distance to the prefecture center.

We further study the association between the distance and educational outcomes by considering whether residents have completed junior or senior high school education. Table 3 presents the results when controlling individual characteristics and county-level fixed effects. The estimated coefficients of the distance from a village to the county center are significantly and negatively associated with completing junior and senior high school. However, insignificance of the estimated coefficients of the villages' distance to the prefecture center is seen for these two types of educational outcomes.

Results in Tables 2 and 3 show that the negative relationship between the villages' distance to the county center and people's education attainment only exists significantly within a county range. Such relationship disappears within a prefecture

Table 3
Spatial segregation of villages and educational attainment: junior and senior high school.

Variables	Junior high school or above			Senior high school or above		
	(1)	(2)	(3)	(4)	(5)	(6)
Ln (Distance to the county center)	–0.0678*** (0.0082)		–0.0675*** (0.0082)	–0.0665*** (0.0087)		–0.0665*** (0.0088)
Ln (Distance to the prefecture center)		–0.0416 (0.0283)	–0.0312 (0.0277)		–0.0129 (0.0342)	–0.0027 (0.0355)
Individual characteristics	Y	Y	Y	Y	Y	Y
County fixed effects	Y	Y	Y	Y	Y	Y
N	13,009	13,009	13,009	13,009	13,009	13,009
R squared	0.3538	0.3350	0.3540	0.1510	0.1201	0.1510

Note: Robust standard errors are in parentheses, which are clustered at the village level. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: Authors calculations.

range, usually including several or even more than ten counties. One reason for this result is that the county-level government of China is responsible for providing 9-year compulsory education and senior high school education to people within its own administration. Another reason is that villagers' decisions on children's education are more likely to respond to economic development in the central area of counties rather than in the central area of a large prefecture. Prefectures in our sample are less developed and do not have enough non-farming jobs for skilled labor. We will discuss this issue in detail in the following section.

5.2. Spatial segregation, educational attainment and acquisition of non-farming work

This section further explores the association between spatial segregation, human capital accumulation and people's occupational acquisitions by running the regression of the Equation (1). According to Column (1) of Table 4, the estimated coefficient of the villages' distance to the county center is significant and negative at the 1% level when controlling for individual characteristics and county fixed effects. Keeping other things equal, a unit increase in the distance to the county center results in a 0.0934 unit decrease in people's acquisition of non-farming work. This indicates that rural residents who are closer to the county center are more likely to find a non-farming job. Column (2) reports a significant and negative relationship between the villages' distance to the county center and the years of education, which is similar to Table 2.

Column (3) focuses on the relationship between residents' educational attainment and their acquisition of non-farming work. We find that educational years are significantly and positively associated with people's acquisition of non-farming work. Keeping other things equal, a unit increase in educational years results in a 0.0515 unit increase in people's acquisition of non-farming work.

Column (4) shows that after adding educational years into the regression, the estimated coefficient of the villages' distance to the county center becomes smaller than that in Column (1). This indicates that educational attainment is likely to be a mediating factor in the association between spatial segregation and rural residents' acquisition of non-farming work. This means that improving human capital

Table 4
Spatial segregation of villages, educational attainment and acquisition of non-farming work.

Variables	Non-farming work	Educational years	Non-farming work	Non-farming work
	(1)	(2)	(3)	(4)
Ln (Distance to the county center)	–0.0934***	–0.7498***		–0.0583***
	(0.0120)	(0.0963)		(0.0099)
Ln (Distance to the prefecture center)	0.0453	–0.1318		0.0515
	(0.0428)	(0.3352)		(0.0353)
Educational years			0.0515***	0.0469***
			(0.0019)	(0.0020)
Individual characteristics	Y	Y	Y	Y
County fixed effects	Y	Y	Y	Y
N	10,545	10,545	10,545	10,545
R squared	0.2679	0.4261	0.3303	0.3432

Note: Robust standard errors are in parentheses, which are clustered at the village level. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: Authors calculations.

through enabling long educational years of people in remote villages is an effective way to increase their chances to obtain higher paid non-farming work. This is an effective way to overcome the impact of spatial segregation and improve people's livelihood resilience in impoverished regions in the long run.

5.3. Heterogeneity analyses

Herein, we further explore whether the association between spatial segregation, educational attainment, and acquisition of non-farming work shows any variation among different groups of individuals and counties. Table 5 reports the results of different groups of individuals. Panel A compares the male group and the female group. The results are twofold. First, spatial segregation of villages is significantly and negatively associated with both educational attainment and people's acquisition of non-farming work for both genders. Second, the association between spatial segregation and acquisitions of non-farming work is mediated by educational attainment in a similar way with little heterogeneity for both the male and female groups (Columns 4 and 8).

Panel B compares the young and old age cohorts by dividing the sample into a younger group (aged 15 to 44) and an elder group (aged 45 to 60). The verified association between spatial segregation, educational attainment and people's acquisition of non-farming work shows little heterogeneity between the young and old groups.

Table 6 reports the heterogeneity analysis of counties at a different economic level and with differences in accessibility to railway. We classify all counties into the developed and less developed groups by using the median of counties' per capita GDP (RMB 14,892, equivalent $2,036) in 2015. Within counties, non-farming opportunities in villages heavily depend on the economic spillover of county centers. The central area of less developed counties with less economic spillovers provides fewer non-farming opportunities to rural residents in remote villages. Thus, rural residents in less developed counties may be more sensitive to spatial distance than those in developed counties. According to Panel A, the association between

Table 5
Heterogeneity analysis: individual level.

Variables	Panel A: Gender group							
	Male sample				Female sample			
	Non-farming work	Educational years	Non-farming work	Non-farming work	Non-farming work	Educational years	Non-farming work	Non-farming work
Ln (Distance to the county center)	–0.0895***	–0.7345***		–0.0548***	–0.0956***	–0.7396***		–0.0609***
	(0.0119)	(0.0972)		(0.0100)	(0.0129)	(0.1005)		(0.0110)
Educational years			0.0518***	0.0472***			0.0515***	0.0469***
			(0.0022)	(0.0024)			(0.0021)	(0.0022)
Individual characteristics	Y	Y	Y	Y	Y	Y	Y	Y
County fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
N	5,698	5,698	5,698	5,698	4,847	4,847	4,847	4,847
R squared	0.2610	0.3873	0.3205	0.3318	0.2712	0.4715	0.3366	0.3511
Variables	Panel B: Age group							
	Younger sample (age 15 to 44)				Elder sample (age 45 to 60)			
	Non-farming work	Educational years	Non-farming work	Non-farming work	Non-farming work	Educational years	Non-farming work	Non-farming work
Ln (Distance to the county center)	–0.0871***	–0.7753***		–0.0509***	–0.1084***	–0.6646***		–0.0761***
	(0.0120)	(0.0970)		(0.0101)	(0.0161)	(0.1232)		(0.0132)
Educational years			0.0508***	0.0466***			0.0537***	0.0486***
			(0.0021)	(0.0022)			(0.0026)	(0.0028)
Individual characteristics	Y	Y	Y	Y	Y	Y	Y	Y
County fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
N	7,234	7,234	7,234	7,234	3,311	3,311	3,311	3,311
R squared	0.2842	0.4354	0.3491	0.3588	0.2338	0.3895	0.2906	0.3124

Note: Ln (Distance to the prefecture center) is controlled in both panels. Robust standard errors are in parentheses, which are clustered at the village level. Significance: $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$.
Source: Authors calculations.

Table 6
Heterogeneity analysis: county level.

Variables	Panel A: per capita GDP in 2015							
	Lower per capita GDP sample				Higher per capita GDP sample			
	Non-farming work	Educational years	Non-farming work	Non-farming work	Non-farming work	Educational years	Non-farming work	Non-farming work
Ln (Distance to the county center)	–0.0911***	–0.7631***		–0.0587***	–0.0957***	–0.7434***		–0.0585***
	(0.0186)	(0.1443)		(0.0160)	(0.0154)	(0.1231)		(0.0124)
Educational years			0.0469***	0.0425***			0.0549***	0.0499***
			(0.0028)	(0.0031)			(0.0026)	(0.0027)
Individual characteristics	Y	Y	Y	Y	Y	Y	Y	Y
County fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
N	5,067	5,067	5,067	5,067	5,478	5,478	5,478	5,478
R squared	0.2921	0.5001	0.3408	0.3527	0.2460	0.3436	0.3173	0.3312
Variables	Panel B: Railway in 2015							
	Railway sample				No-railway sample			
	Non-farming work	Educational years	Non-farming work	Non-farming work	Non-farming work	Educational years	Non-farming work	Non-farming work
Ln (Distance to the county center)	–0.1272***	–0.6733***		–0.0981***	–0.0900***	–0.7595***		–0.0538***
	(0.0325)	(0.2194)		(0.0300)	(0.0129)	(0.1046)		(0.0104)
Educational years			0.0485***	0.0431***			0.0523***	0.0477***
			(0.0043)	(0.0041)			(0.0021)	(0.0023)
Individual characteristics	Y	Y	Y	Y	Y	Y	Y	Y
County fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
N	2,501	2,501	2,501	2,501	8,044	8,044	8,044	8,044
R squared	0.1999	0.3188	0.2232	0.2455	0.2878	0.4399	0.3607	0.3729

Note: Ln (Distance to the prefecture center) is controlled in both panels. Robust standard errors are in parentheses, which are clustered at the village level. Significance: $^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$.
Source: Authors calculations.

the villages' distance to the county center, educational attainment and people's access to non-farming jobs is stronger in counties with lower per capita GDP.

The construction of transport infrastructure improves the connection of a county with larger markets and may affect the association between the distance to the county center, educational attainment and people's acquisition of non-farming work. Panel B divides the sample counties into two groups according to whether a county opened railways in 2015. Columns (1) and (5) in Panel B show that the negative association between the distance to the county center and educational years is stronger for counties without a railway. This implies that railways may enlarge the gap of people's educational attainment between the villages close to the county center and the remote ones. Moreover, the negative association between the distance to the county center and acquisition of non-farming work is mediated by educational attainment in a similar way for counties with and without railways.

6. Discussion and conclusion

Modern China represents a very special case of rural development, maybe unique in the world, due both to the scale and the speed of changes affecting its huge and populous rural areas.

The targeted poverty alleviation strategy in China has lifted 70.17 million rural population out of poverty after years of intensive input and assistance. A big concern and work focus in the post-poverty era are to consolidate the achievements of poverty reduction and avoid people's return to poverty due to unexpected risks and shocks. In this process, improving poor households' livelihood resilience against risks and shocks through accumulated human capital plays an important role in strengthening people's capacity for pursuing better-off livelihood. This is also an important way to shift from external assistance to poor people's self-driven development through increased endogenetic power.

Our study presents evidence of the links between spatial segregation, human capital and people's livelihood resilience in the impoverished regions of China. The research findings show that spatial segregation is significantly and negatively associated with people's educational attainment and their acquisition of non-farming work. Thus, rural residents living in villages farther from the county center tend to accumulate less human capital and are less likely to obtain non-farming work than those who are closer to the county center. The mediating effect analysis further shows that spatial isolation mainly reduces the propensity of people's access to non-farming jobs by reducing their human capital accumulation. As junior or senior high schools are mainly located in the central areas of counties, the distance from villages to high schools implies the cost of rural people's educational attainment. The longer the distance to the county center, the less educational attainment people may obtain. And this in turn decreases the chances of people's acquisition of non-farming employments which are normally located in downtown areas of each county. For the impoverished counties in our sample, the role of spatial segregation in affecting people's human capital accumulation and access to non-farming jobs could be even more significant if the county has a lower economic level and less developed transportation infrastructure.

In today's China, economic growth places more emphasis on the input of knowledge and demands more supply of innovative and skilled laborers. As for liveli-

hood resilience of people living in remote areas, the policy implications based on our research findings are three folded. First, the transportation infrastructure between villages and county centers needs to be constructed and improved to decrease spatial segregation and improve people's access to education, employments and services. Second, more input is needed to guarantee the supply of rural education to remote villages by building schools, improving teaching facilities, and attracting teachers. Third, the county economy in those impoverished regions needs to be further developed to offer people more job opportunities and attract a highly qualified labor force.

This study still has some deficiencies. Due to data availability, we cannot accurately calculate the actual traveling time from a village to the center of a county or prefecture. Using geographical distance as a proxy variable for spatial segregation may bias the estimated results. In addition, the data of rural residents' income is not available. Finally, although we controlled for the county-level fixed effect in the regression, we do not take into account the geographical characteristics of villages, which might also bias the estimated results.

As the quantitative analysis showed, geographical location plays a very important role in enabling rural development, as proximity to the cities, mainly to the county centers, becomes a crucial factor for adding value to the human capital of impoverished regions through education and providing employment.

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