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Article

Factors influencing rural educational investment under the digital divide: A QCA study

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Abstract: Given the issues of urban-rural educational inequality and difficulties for children from poor families to succeed, this study explores the impact mechanism of internet usage on rural educational investment in China within the context of the digital divide. Using data from the 2019 China Household Finance Survey (CHFS), this study analyzed the educational investment decisions of 2064 rural households. Results indicate that in the Eastern region, a high level of educational investment is primarily influenced by the per capita income of the family, with social capital and internet usage also playing supportive roles. In the Northeastern region, the key factor is the diversity of internet usage, specifically using both a smartphone and a computer. In the Central region, factors such as the diversity of internet usage, subjective risk attitudes, the appropriate age of the household head, and per capita income of the family contribute to higher levels of educational investment. In the Western region, the dominant factors are the diversity of internet usage, subjective usage and per capita income of the family. These factors enhance expected returns on the high level of educational investment and boost farmers' confidence. High internet usage rates significantly promote diverse and stable educational investment decisions, providing evidence for policymakers to bridge the urban-rural education gap.

Keywords: rural educational funding; digital inequality; qualitative comparative analysis; socioeconomic barriers; technological access in education

1. Introduction

Against the backdrop of widening income and wealth gaps in society, equalizing human capital investment is crucial for achieving common prosperity and social equity. Education, as a core indicator of human capital, has become a dominant factor affecting economic status in rural China (Zhang et al., 2015). It not only enhances the economic status of farmers through occupational mobility, but is also the key to blocking the intergenerational transmission of poverty (Bird and Higgins, 2011; Emran et al., 2023). For disadvantaged farmers, education-oriented human capital investment enhances subjective well-being (Wu et al., 2020), increases access to higher-level occupations (Taylor et al., 2012), and promotes mobility of the poorer class to the higher class (Haskins et al., 2009), thereby reducing poverty.

Most studies acknowledge the positive impact of public educational funding on poverty reduction (Jung et al., 2015). However, the education gap still exacerbates the relationship between poverty and the entrenchment of disadvantaged classes. Many studies emphasize the role of fiscal education expenditure in breaking the cycle of intergenerational poverty (Boldrin, 2005; Castañeda and Aldaz-Carroll, 1999; Rose and Dyer, 2008). Hanjra et al. (2009) argue that the unequal distribution

of public educational resources and the irrational structure of household educational investment limit the effectiveness of education in alleviating poverty (Yang et al., 2014). Thus, merely increasing the amount and supply of educational funding cannot fully address the challenge of the predicament of difficulties for children from poor families to succeed. The key lies in targeted poverty alleviation and improving education quality (Saci, 2023; Yang and Liu, 2021; Zhang, 2020). To narrow the education gap and achieve educational equity, it is essential to integrate online and offline education, providing high-quality remote learning resources to rural and remote impoverished areas.

The digital divide in education is mainly reflected in two aspects, which are educational informatization and household investment in children's education. Zhao et al. (2023) argue that educational informatization could enhance rural students' cognitive abilities and learning outcomes, addressing issues of insufficient funding and lack of teachers in rural education. However, realizing educational informatization requires support from local public finances and attention to household investment in children's education. Due to data availability, research on the relationship between household educational investment and poverty is limited, and the impact of internet usage on educational investment in the context of the digital divide has not been fully verified. Lanzi (2007) and Kucharčíková et al. (2015) suggest that information capital is difficult to convert directly into human capital, implying that internet usage may not significantly increase household investment in children's education. Therefore, the impact and mechanism of internet usage on rural educational investment under the digital divide requires further exploration.

According to Odhon'g and Omolo (2015) human capital theory, education is one of the most important avenues for human capital investment. Klasen and Lamanna (2008) and Bhuyan et al. (2020) point out that expenditures on educational investment in children increase household economic burdens and cannot be directly converted into income-enhancing effects in the short term. Thus, whether households invest in education is mainly influenced by the expected return on investment. Internet usage may improve the expected rate of returns on educational investment and reduce information processing costs (El Bilali and Allahyari, 2018; Saggi and Jain, 2018; Thompson and Garbacz, 2007). These factors help optimize rural adolescents' knowledge structure, improve academic performance, and meet the expected returns on educational investment, enhancing the willingness to invest. However, the blindness of some rural households in education investment decision-making further increases the uncertainty of the return on investment in education (Callahan, 2013; Ji et al., 2021), which may lead to the predicament of 'poverty caused by education' (Davis and Lopez-Carr, 2014; Steinert et al., 2018). Additionally, the internet may also lower the expected returns on educational investment due to the influence of false information and online games, which may affect adolescents' academic performance and weaken households' willingness to invest in education. Therefore, the impact mechanism of internet usage on rural educational investment decisions needs further in-depth analysis and discussion.

Besides, China's vast geographic expanse and diverse economic landscape result in significant regional differences, particularly in areas such as economic

development, educational resources, and infrastructure (Wu et al., 2021). These disparities have been well-documented in the literature and are critical for understanding variations in socioeconomic outcomes across the country. By analyzing data across the central, eastern, northeastern, and western regions, this study aims to uncover how these regional differences influence the impact of internet usage on educational investment, providing a more nuanced understanding of the underlying dynamics.

2. Literature review

2.1. Decision of rural educational investment

The decision of rural households to invest in their children's education is influenced by both costs and benefits. Under the digital divide, the internet era affects the expected returns on investment in these two aspects, thus impacting educational investment behaviors. On one hand, internet-based remote learning could reduce educational investment costs, such as time and miscellaneous expenses, and improve the symmetry of educational information (Mustofa et al., 2013). It also enhances the perceptions of education's role in social mobility (Rovai, 2007). Low information costs associated with internet usage increase the expected returns on educational investment, which in turn encourages households to invest more in their children's education. On the other hand, the internet provides educational modes like live webcasts, online learning tools, and recorded lessons. These high-quality, low-cost, replayable resources improve students' study efficiency (Hill et al., 2013). Cross-regional access to high-quality online educational resources further boosts the expected returns on educational investment. Although the internet poses risks of addiction among minors, current anti-addiction systems and teenage modes help mitigate this issue, enhancing the expected returns on educational investment (Philander et al., 2017). Therefore, rural households are more likely to increase their investment in their children's education based on these higher expected returns.

2.2. Social capital and rural educational investment

Social capital plays a critical role in rural households' educational investment decisions. According to Ferris et al. (2017), higher levels of social capital diversify information channels and reduce information costs, thereby decreasing the uncertainty in investment decisions. Additionally, social capital formed through family and social networks can increase the likelihood and options for investing in children's education (Adelman, 2013). With the spread of the internet, social media has become a crucial means of obtaining information and communication. The use of social media significantly enhances social capital (Ali-Hassan et al., 2015; Cao et al., 2015). Thus, internet usage not only broadens the information channels available to rural households but also potentially increases social capital accumulation. This, in turn, improves social efficiency and reduces costs.

2.3. The risk of rural educational investment

For rural households, educational investment is a long-term process with

inherent risks. Investing in children's education consumes costly inputs, and may not lead to change in social class. As a result, many households choose to reduce educational investment and instead encourage their children to enter the labor market earlier to gain economic benefits. The uncertain returns on educational investment make households prefer to obtain intuitive economic and social status improvements. Additionally, limited access to information and knowledge restricts rural households' decision-making (Djurfeldt et al., 2018; Zheng and Lu, 2021). However, internet usage can mitigate risk aversion by providing timely information updates. The internet expands the channels through which households obtain useful information and acquire new knowledge and concepts. This helps them to accumulate human capital and enhances their ability for risk resilience.

2.4. Public education quality and rural educational investment

The current state of education in China shows that rural households are often limited by the low quality of public education in their areas (Chen et al., 2020; Yi et al., 2012). This results in their children lacking access to high-quality public education, reducing satisfaction with public education and affecting the positive impact of internet usage on educational investment. Compared to economically developed cities, the quality of rural public education is in decline, with quality educational opportunities increasingly shifting to urban areas (Miller, 2015). In the context of declining public education quality and diverse online education modes, rural households rely more on online education to bridge the gap. On the one hand, the spread and flexibility of information via the internet challenge traditional views of rural households, making them aware of the internet's importance in cracking the intergenerational transmission dilemma of poverty and achieving class leap. On the other hand, the Internet provides rural households with diverse employment information, which can partially improve educational dilemmas (Martínez-Domínguez and Mora-Rivera, 2020). Consequently, rural households recognize the internet's role in enhancing educational investment, in the hope of obtaining higher future returns and achieving a leap in social class.

3. Methodology

Qualitative Comparative Analysis (QCA) is a method based on set theory and Boolean algebra, used to examine how configurations of antecedents' influence outcomes (Duşa, 2019; Thiem, 2022). Traditional regression methods aim to estimate the net effect of independent variables on dependent variables. In contrast, QCA combines the strengths of quantitative and qualitative analysis, following theoretical sampling principles and offering a case-based configurationally approach (Greckhamer et al., 2018; Parente and Federo, 2019). It focuses on necessary and sufficient conditions, where necessary conditions are prerequisites for an outcome, and sufficient conditions refer to the antecedents being able to sufficiently produce the outcome (Achmetli et al., 2019; Kazdin et al., 1997). QCA includes three types, which are called multi-value set, clear set, and fuzzy set (fsQCA). Among these, fsQCA has become a vital method in social sciences for capturing causal complexity due to its higher data accuracy.

However, there are limitations in using QCA for analyzing configurations of rural educational investment. First, there is limited capacity to handle large samples. Although scholars recognize QCA's application in large sample analysis, the number of cases in most of the studies is still around 30, which has not addressed the issue of decreased model consistency and coverage indicators in large sample studies (Fainshmidt et al., 2020; Fernández-Esquinas et al., 2021; Ide and Mello, 2022). Second, the number of condition variables is limited, as increasing them leads to an exponential increase in configuration combinations. Currently, the number of condition variables in most studies is typically from 4 to 9 (Marx, 2006; Thomas et al., 2014; Schneider, 2019), significantly reducing the effectiveness of the analysis. To address these issues, this study improves and uses fsQCA to analyze the complex causal mechanisms of internet usage on rural educational investment in the context of the digital divide. fsQCA, compared to traditional QCA, uses a fuzzy-set approach that allows for data calibration across a continuum rather than binary categorizations. This method enhances the model's ability to handle larger samples. It improves consistency and coverage indicators, addressing the limitations of traditional QCA related to sample size and the number of condition variables. Additionally, fsQCA excels at managing multiple causal configurations and exploring causal complexity, which enriches the analysis of the digital divide's impact on rural educational investment.

3.1. Data, measurement and calibration

The data for this study comes from the 2019 China Household Finance Survey (CHFS 2019). This research aims to use the QCA method to explore the impact of internet usage on rural educational investment and its mechanisms. 'Rural areas' in China are defined as administrative units consisting of a township and surrounding villages (Zhao and Yu, 2020). These areas, established as rural in 1984, are characterized by solid economic and social ties and are defined by a population cap: no more than 20,000 residents in the entire region and at least 2000 in the township. In this study, 'rural area' refers to the built-up areas of selected towns that perform administrative functions and their adjacent villages. The CHFS dataset, the primary data source for this study, is a comprehensive national survey conducted in China to collect micro-level information on various aspects of household finance, including housing assets, financial wealth, liabilities, credit constraints, income, consumption, social security, and educational investment. The data is inherently stratified into four major regions: central, eastern, northeastern, and western China. This regional categorization is a key feature of the dataset, allowing researchers to explore regional disparities and their influence on the outcome. Thus, performing a regional analysis is both logical and essential for fully utilizing the dataset's potential and understanding the contextual factors that may differ across these regions. Considering the research objectives of this study, there is a need to use both individual-level and household-level data. Relevant data from the CHFS 2019 database were carefully matched, and any missing variables or outliers were excluded, resulting in a final sample of 2064 rural households.

3.1.1. Outcome variable

This study uses investment in children's education as the outcome variable. Most previous studies often used years of education and academic performance as measures of investment in children's education (Yurk Quadlin, 2015; Zhan, 2006). However, these two elements are affected by subjective factors and policy changes, making them cannot objectively and accurately reflect the real importance that families attach to their children's education (Darling-Hammond and Cook-Harvey, 2018; Dewald et al., 2010; Gallimore et al., 1993). Dufur et al. (2013) argue that educational expenditure more objectively reflects a family's economic investment in their children's education (Jensen and Nielsen, 1997). Therefore, this study selects the average expenditure on educational training for minors as a proxy variable for educational investment. When using the QCA method, the measurement variables need to be calibrated and transformed into set concepts (Meuer and Rupietta, 2017). For the outcome variable, this study first takes the logarithm of the data and then directly calibrates raw data for transformation. Following Gonçalves et al. (2016), the thresholds for full membership, crossover point, and full non-membership are set at 95%, 50%, and 5% respectively.

3.1.2. Antecedent variables

In this study, internet usage is defined by whether the household head uses a smartphone or if the household owns a computer. Although rural internet infrastructure is relatively well-developed, access methods are limited mainly to smartphones and computers (including desktops, laptops, and tablets). Other methods such as smart TVs, gaming consoles, and internet-enabled devices like smart home assistants also exist, but they are less prevalent in the selected rural areas. Therefore, this study focuses on the most widely available devices, two questions from the database were selected for this study, which are 'Does your household own a computer (desktop/laptop/tablet)?' and 'What type of phone do you currently use?' The characteristic of questions reflects the practical constraints faced in rural settings, which are central to understanding internet access patterns in rural areas. If the household head uses a smartphone or the household owns a computer, it is considered to be using the internet, coded as 1, and vice versa is 0, which is labeled as variable *A*. To compare the impact of the diversity of internet access channels on educational investment, variable *B* was set. This variable captures not merely the quantity but the diversity of internet access, as different devices facilitate varied interactive experiences and learning opportunities. For instance, smartphones offer portable and instant access to information, suitable for dynamic learning environments and communication. In contrast, computers provide a more stable and extensive platform for conducting in-depth learning tasks and engaging with complex educational applications. Diverse internet access can enhance students' learning experiences and boost their motivation, which may lead to better academic performance. According to Eccles and Harold (2013), parents often increase their investment in their children's education after seeing improvements in their academic results. In this study, the household is coded as 1 for variable *B* if it uses both a smartphone and a computer, indicating access through two distinct internet channels. Conversely, if only one device is used, or if no devices are used, the variable *B* is

coded as 0. Given this definition, if $B = 1$ (indicating both devices are present), A must also equal 1, as A represents the presence of at least one device. Thus, $B = 1$ is a subset of $A = 1$. When $B = 0$ (indicating either only one device is present or no devices are present), A may be either 0 or 1. Specifically, $A = 1$ remains consistent with $B = 0$ if there is only one device, while $A = 0$ is also consistent with $B = 0$, indicating the absence of both devices. Consequently, $A = 0$ is a subset of $B = 0$, and $B = 0$ encompasses scenarios where $A = 0$ or $A = 1$. This overlap highlights that while A (having either a smartphone or a computer) signifies basic digital access, B (having both devices) represents a more comprehensive digital environment, which is likely associated with the higher level of educational investment. The presence of B underscores the importance of the diversity of digital access for enhancing educational opportunities and supporting investments, demonstrating that comprehensive access is crucial for maximizing educational outcomes.

Another antecedent is social capital. Social capital in rural households is based on geographical and kinship networks. A broader kinship network implies a wider social network (Dunbar and Spoors, 1995). Thus, the question 'Last year, how much cash or non-cash assistance did your household give to relatives and non-relatives, excluding parents and parents-in-law?' was used to measure social capital. The data was logarithmized and labeled as variable *C*, with the same calibration standards as those of the outcome variable.

Risk attitudes are categorized into subjective and objective risk attitudes. Subjective risk attitude reflects personal characteristics and self-perception, while objective risk attitude depends on the family's disposable resources, indicating risky investment behavior (Chattopadhyay and Dasgupta, 2015; García-Mainar and Montuenga, 2024). Based on this, this study selected 'If you had a sum of money, what kind of investment project would you prefer?' as the proxy variable for subjective risk attitude, coded as variable *D*. The question 'Does your household currently hold financial products?' was selected as the proxy variable for objective risk attitude, coded as variable *E*. Following Dusa et al. (2024), subjective risk attitude has five levels, calibrated using 5, 3, and 1. For objective risk attitude, 1 indicates holding financial products (high risk attitude), and 0 indicates not holding them (low risk attitude).

In this study, public education satisfaction was selected to measure rural family's satisfaction with the basic public education services provided by the government. The question 'Are you satisfied with the basic public education services provided by the government?' was set as variable *F*. This variable is a five-point scale, so calibrated using 5, 3, and 1.

Finally, the antecedent conditions at the individual and household levels of household heads are selected. Personal characteristics include the age and health level of the household head. The health level of the household head affects household expenditures, and poorer health would increase medical expenses, reducing educational investment. Therefore, age is calibrated using the same calibration as the outcome variable, and health level is calibrated using a five-level scale (5, 3, 1). Family characteristics include average education level, household size, and per capita income. Higher average education levels typically result in greater emphasis on children's education, leading to higher educational investment

(Hannum and Buchmann, 2003). Larger household sizes, despite potentially having more social capital, may spread educational investment thin (Dasgupta and Serageldin, 2000). Higher per capita income increases the household's capacity to invest in education. Per capita income is firstly logarithmized, and other variables are directly calibrated in the same way as the outcome variable. Variable details are shown in **Table 1**. The descriptive statistics of variables are shown in **Table 2**.

Table 1. Variable details.

Variable type	Variable name		Symbol	Definition
Outcome	Children's educational investment		*Y*	Average expenditure of farmers on education and training of children.
Antecedents	Internet usage		*A*	If the householder uses a smartphone or owns a computer at home, the variable is recorded as 1, otherwise it is recorded as 0.
			B	If farmers use smartphones and have computers at home, the variable is 1, and if they only use smartphones or have computers or neither device at home, the variable is 0.
	Social capital		*C*	Select "Last year, except for parents and in-laws/in-laws, how much cash or non-cash did your family give to other relatives and non-relatives" to measure, and deal with the data logarithmically.
	Risk attitude	Subjective risk attitude	*D*	Select "If you have a sum of money, what kind of investment project would you prefer" as the proxy variable of subjective risk attitude.
		Objective risk attitude	*E*	Select "Does your family hold wealth management products now" as the proxy variable of objective risk attitude.
	Public education satisfaction		*F*	Select "Are you satisfied with the basic public education services provided by the government" to measure, and divide the satisfaction into 1–5, where 1 means very satisfied and 5 means very dissatisfied.
	Household characteristics	Age of head of household	*G*	Age of head of household
		Health level of head of household	*H*	The health level of householders is 1–5, and the higher the value, the worse the health level.
	Family characteristics	Average educational level of families	*I*	Average educational level of families
		Per capita income of the family	*J*	Per capita income of the family
		Household size	*K*	Family population size

Table 2. The descriptive statistics of variables.

Variable type	Variable name	Symbol	Index	Northeast (*n* = 191)	Western (*n* = 275)	Central (*n* = 394)	Eastern (*n* = 1204)
Outcome	Children's educational investment (log)	*Y*	Max	11.918	12.206	12.429	11.918
			Min	2.079	2.079	2.079	2.079
			Mean	8.586	8.595	8.493	8.437
Antecedents	Internet usage (0 or 1)	*A*	Mean	0.995	0.996	0.997	0.992
		B	Mean	0.696	0.676	0.622	0.596
	Social capital (log)	*C*	Max	11.29	10.82	12.206	11.513
			Min	3.689	4.605	2.996	3.401
			Mean	7.546	7.531	7.398	7.551

Table 2. (*Continued*).

Variable type	Variable name		Symbol	Index	Northeast (n = 191)	Western (n = 275)	Central (n = 394)	Eastern (n = 1204)
Antecedents	Risk attitude	Subjective risk attitude (scale 1–5)	*D*	Mean	3.814	3.869	4.022	4.062
		Objective risk attitude (0 or 1)	*E*	Mean	0.157	0.098	0.124	0.086
	Public education satisfaction (scale 1–5)		*F*	Mean	2.246	2.316	2.180	2.184
	Household characteristics	Age of head of household	*G*	Max	91	92	99	99
				Min	9	9	9	9
				Mean	56.639	52.836	54.662	58.362
		Health level of head of household (scale 1–5)	*H*	Mean	2.685	2.796	2.568	2.664
	Family characteristics	Average educational level of families (scale 1–9)	*I*	Mean	3.219	3.156	3.142	3.353
		Household size (scale 1–9)	*J*	Mean	1.392	1.425	1.393	1.361
		Per capita income of the family (log)	*K*	Max	14.509	14.509	13.821	14.850
				Min	7.003	7.601	6.454	6.908
				Mean	11.240	11.270	11.049	11.045

4. Results

4.1. Necessary condition analysis

Necessary Condition Analysis (NCA) and Sufficient Condition Analysis (SCA) are two fundamental strategies in QCA. First, this study conducted an NCA for high rural educational investment to test whether 11 conditions and their non-set states are necessary for high rural educational investment. Necessary conditions are those that exist for each path (set of states) in which the outcome occurs (Page, 2006; Vergne and Durand, 2010). The analysis of the necessity of high rural educational investment is shown in **Table 3**.

Table 3. Necessary conditions for high-level rural educational investment analysis.

	Northeast		Eastern		Central		Western	
	Consistency	**Coverage**	**Consistency**	**Coverage**	**Consistency**	**Coverage**	**Consistency**	**Coverage**
A	0.998	0.529	0.990	0.520	0.994	0.551	0.995	0.514
~A	0.002	0.240	0.010	0.434	0.006	0.325	0.005	0.320
B	0.740	0.561	0.633	0.551	0.686	0.606	0.747	0.566
~B	0.260	0.451	0.367	0.472	0.314	0.455	0.253	0.401
C	0.993	0.529	0.999	0.521	0.999	0.553	0.999	0.515
~C	0.016	0.845	0.009	0.949	0.010	0.663	0.008	0.991
D	0.588	0.591	0.691	0.585	0.677	0.635	0.649	0.622
~D	0.627	0.695	0.505	0.676	0.523	0.692	0.597	0.659
E	0.189	0.634	0.104	0.624	0.151	0.669	0.128	0.669
~E	0.811	0.507	0.896	0.509	0.849	0.532	0.872	0.496
F	0.443	0.811	0.419	0.784	0.392	0.765	0.464	0.776
~F	0.845	0.625	0.873	0.626	0.871	0.666	0.847	0.626
G	0.638	0.652	0.623	0.661	0.628	0.675	0.625	0.658
~G	0.639	0.697	0.646	0.677	0.625	0.702	0.664	0.664

Table 3. (*Continued*).

	Northeast		**Eastern**		**Central**		**Western**	
	Consistency	**Coverage**	**Consistency**	**Coverage**	**Consistency**	**Coverage**	**Consistency**	**Coverage**
H	0.553	0.714	0.561	0.707	0.514	0.724	0.626	0.724
~H	0.764	0.681	0.735	0.648	0.762	0.685	0.725	0.668
I	0.372	0.762	0.399	0.758	0.375	0.826	0.369	0.794
~I	0.879	0.618	0.851	0.608	0.864	0.632	0.914	0.615
J	0.739	0.727	0.714	0.725	0.766	0.767	0.741	0.761
~J	0.593	0.674	0.598	0.635	0.537	0.652	0.607	0.622
K	0.147	0.939	0.142	0.929	0.130	0.864	0.144	0.878
~K	0.978	0.562	0.979	0.552	0.986	0.590	0.986	0.552

Note: the notation ~ means the absence of the variable.

As shown in **Table 3**, in the Northeastern, Eastern, and Central regions, except for conditions *A*, *C*, and *~K*, the consistency of all other conditions and their non-set states is below the threshold of 0.9. In the Western region, except for conditions *A*, *C*, *~I*, and *~K*, the consistency of all other conditions and their non-set states is also below 0.9. Thus, it can be preliminarily concluded that conditions *A*, *C*, and *~K* are necessary for high rural educational investment in the Northeastern, Eastern, and Central regions. This implies that these conditions are required to achieve high rural educational investment under the digital divide. Specifically, the use of smartphones or computers at home, the possession of social capital, and the smaller household size. The presence of smaller household sizes with such high consistency challenges the typical assumption that larger family size is always necessary for higher educational investment. While larger households may bring more social capital, they face the challenge of distributing educational resources among more members, potentially reducing the effectiveness of those investments. In contrast, smaller households, though they may have less overall social capital, can direct a larger share of their resources to each child's education, resulting in higher individual educational investment. This makes *~K* (smaller household size) a reasonable and necessary condition for achieving higher educational investment, as it allows families to concentrate their financial, emotional, and time resources on fewer children, thereby enhancing the quality and impact of the educational support they can provide. For the Western region, conditions *A*, *C*, *~I*, and *~K* appear to be necessary. This means using a smartphone or computer at home, having certain social capital, non-higher education levels of family members, and smaller family sizes are required. Among these, *~I*, denoting 'non-higher education levels of family members,' suggests that there exists an expectation to facilitate social mobility for children through education. This expectation can subtly influence the family's decisions regarding educational investment. In addition, other single condition variables have low explanatory power for high rural educational investment. Therefore, it is necessary to further explore whether combining these conditions in different configurations can better explain high rural educational investment under the digital divide.

As shown in **Table 4**, in the Eastern, Central, and Western regions, except

conditions *A*, *C*, and ~*K*, the consistency of all other conditions and their non-set states falls below the 0.9 threshold. Similarly, in the Northeast region, except for conditions *A*, *C*, ~*E*, and ~*K*, the consistency of all other conditions and their non-set states is also below 0.9. The analysis reveals that both high-level and non-high-level educational investment configurations consistently include *A*, *C*, and ~*K*. This indicates that these factors are universally significant across different levels of educational investment. While *A*, *C*, and ~*K* are necessary conditions for educational investment, the distinction between high and non-high levels of investment likely depends on the interaction of these conditions with other variables. Therefore, *A*, *C* and ~*K* form the foundational conditions for educational investment, but the final investment level is shaped by how these factors interact with and are supported by other conditions.

Table 4. Necessary conditions for non-high-level rural educational investment analysis.

	Northeast		**Eastern**		**Central**		**Western**	
	Consistency	**Coverage**	**Consistency**	**Coverage**	**Consistency**	**Coverage**	**Consistency**	**Coverage**
A	0.991	0.471	0.986	0.480	0.985	0.483	0.990	0.486
~*A*	0.008	0.760	0.013	0.566	0.015	0.720	0.010	0.680
B	0.647	0.439	0.557	0.449	0.549	0.429	0.602	0.434
~*B*	0.353	0.549	0.443	0.528	0.451	0.579	0.398	0.599
C	0.997	0.476	0.999	0.483	0.994	0.487	0.999	0.489
~*C*	0.014	0.642	0.009	0.995	0.016	0.933	0.008	0.999
D	0.694	0.625	0.739	0.580	0.706	0.586	0.675	0.614
~*D*	0.546	0.543	0.472	0.586	0.518	0.606	0.585	0.613
E	0.121	0.366	0.068	0.376	0.093	0.363	0.067	0.331
~*E*	0.878	0.493	0.932	0.491	0.907	0.503	0.933	0.504
F	0.435	0.716	0.439	0.761	0.450	0.777	0.467	0.744
~*F*	0.885	0.588	0.876	0.583	0.844	0.570	0.860	0.604
G	0.690	0.631	0.668	0.636	0.649	0.639	0.647	0.647
~*G*	0.619	0.605	0.644	0.625	0.641	0.614	0.658	0.625
H	0.601	0.695	0.570	0.666	0.559	0.697	0.620	0.682
~*H*	0.752	0.601	0.749	0.612	0.750	0.597	0.749	0.655
I	0.401	0.734	0.407	0.717	0.372	0.726	0.399	0.815
~*I*	0.870	0.554	0.862	0.571	0.897	0.580	0.890	0.575
J	0.680	0.600	0.629	0.592	0.597	0.571	0.611	0.597
~*J*	0.691	0.704	0.708	0.696	0.738	0.727	0.756	0.735
K	0.151	0.863	0.142	0.864	0.154	0.913	0.158	0.913
~*K*	0.989	0.510	0.988	0.516	0.973	0.515	0.979	0.521

Note: the notation ~ means the absence of the variable.

4.2. Sufficient condition analysis and conformational results

Configuration analysis evaluates whether combinations of conditions constitute sufficient conditions for the outcome. Using fsQCA 3.0 software, this study analyzed the configurations leading to high rural educational investment. Thiem (2022)

suggests that in QCA applications, smaller datasets can use lower frequency thresholds, such as 1 or 2, due to the low frequency of each condition combination, while higher frequency thresholds, such as 3 or above, are more suitable for large datasets to ensure robustness by considering only more common and significant combinations.

Given the regional breakdown in this study, different frequency thresholds were applied based on the sample sizes: 2 for the Northeast region (191 samples) and the Western region (275 samples), which are relatively small; 4 for the Central region (394 samples), which is moderate in size; and 10 for the Eastern region, which has the largest sample size of 1204, with a raw consistency threshold set to 0.80, not less than the standard 0.75 (Wang, 2023). This approach produced complex, parsimonious, and intermediate solutions, with the fsQCA results shown in **Tables 5–8.**

Table 5. Sufficient configurations for rural educational investment under the digital divide of the northeast region.

	Configurations of northeast							
	1-high	**2-high**	**3-high**	**4-high**	**5-high**	**1-low**	**2-low**	**3-low**
A	·	·	·	·	·	·	·	·
B	●	●	●	●	●		·	⊗
C	·	·	·	·	·	·	·	·
D	⊗	⊗	·	⊗	⊗	●	●	⊗
E		⊗	⊗	⊗	⊗	⊗	⊗	⊗
F	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
G	⊗	·	⊗		·	⊗		·
H	⊗	·	⊗	⊗		⊗	⊗	●
I	⊗	⊗	●	⊗	⊗	⊗	⊗	⊗
J	·		⊗	·	·	⊗	⊗	⊗
K	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Raw coverage	0.245	0.183	0.127	0.221	0.203	0.297	0.220	0.095
Unique coverage	0.075	0.012	0.047	0.001	0.007	0.674	0.038	0.048
Consistency	0.903	0.830	0.887	0.897	0.855	0.877	0.858	0.875
Overall solution consistency	0.834					0.850		
Overall solution coverage	0.397					0.382		

Note: ● = core causal condition present; ⊗ = core causal condition absent; and ⊗ = edge condition; blank = dispensable.

The results of the study show that both the complex and intermediate solutions of this study produced the same combination of conditions with the same values of consistency and coverage of the solutions. Therefore, this study used the intermediate solution with moderate complexity to interpret the results and the parsimonious solution to identify core conditions. Following Thiem's (2022) method, the results are presented to better illustrate the pathways to high rural educational investment. The configuration analysis results are shown in the following tables.

Table 5 presents the configurations explaining rural educational investment in the Northeastern region. In the Northeast region, the consistency values for the five configurations leading to high-level rural educational investment are 0.903, 0.830, 0.887, 0.897, and 0.855. The overall consistency is 0.834, with each configuration also having a consistency greater than 0.8. This indicates that the five high-level configurations can all be considered sufficient conditions influencing high-level rural educational investment. The overall coverage is 0.397, indicating that these configurations can explain around 40% of the cases with high rural educational investment.

For low-level rural educational investment, the consistency values for the three configurations are also above 0.8. The overall consistency for these configurations is 0.850, with a coverage of 0.382. This means that these configurations can explain about 38% of the cases with a low level of rural educational investment.

In the analysis of high-level educational investment in the Northeast region, Configuration 1 shows a consistency of 0.903 and a raw coverage of 0.245. This indicates that this configuration effectively explains 24.5% of the sample cases. The unique coverage is 0.075, meaning that 7.5% of the cases can only be explained by this configuration. In this configuration, two key factors play a decisive role in driving high-level educational investment. The first is the diversity of household internet usage (*B*), where the family uses both a smartphone and a computer. This is seen as a core condition that promotes higher educational investment, suggesting that families with greater digital access are more likely to value education. The second factor is the absence of subjective risk attitude (*D*), indicating that families are less influenced by subjective risk assessments when making investment decisions, and are therefore more inclined to allocate resources to their children's education.

Additionally, some edge conditions also contribute to high educational investment. Basic internet usage (*A*), while not as critical as the diversity of internet usage (*B*), still supports increased investment in education. Social capital (*C*) and higher per capita family income (*J*) also provide favorable edge conditions for high-level educational investment. On the other hand, the absence of certain edge conditions, such as enough public education satisfaction (*F*), the appropriate age of the household head (*G*), the higher health level of the household head (*H*), higher average family educational level (*I*), and bigger household size (*K*), does not hinder the occurrence of high-level educational investment. Lastly, objective risk attitude (*E*) does not play a significant role in this configuration, indicating that the presence or absence of an objective risk attitude has little impact on educational investment.

In Configurations 2, 4, and 5, the consistency values are 0.830, 0.897, and 0.855 respectively. Besides, the raw coverage values of these configurations are 0.183, 0.221, and 0.203, showing that these configurations explain about 18.3%, 22.1%, and 20.3% of the sample cases. In these configurations, the diversity of internet usage (*B*) and the absence of subjective risk attitude (*D*) are both core conditions. It highlights that diverse internet access and investment decisions not influenced by subjective risks are key factors in promoting high-level educational investment. Additionally, basic internet usage (*A*) and enough social capital (*C*) are present as edge conditions, further supporting a higher level of educational investment. Meanwhile, the lack of objective risk attitude (*E*), low public education satisfaction

(*F*), lower average family educational level (*I*), and smaller household size (*K*) do not significantly impact high-level educational investment in these configurations.

However, each configuration shows some differences in edge conditions. In Configuration 2, the appropriate age of the household head (*G*) and good health (*H*) are considered edge conditions that support high-level educational investment. Conversely, per capita family income (*J*) is deemed negligible in this configuration, indicating that it has little effect on the outcome. In Configuration 4, the absence of good health (*H*) is seen as an edge condition, while the age of the household head (*G*) is negligible, yet sufficient per capita family income (*J*) still provides some support. In Configuration 5, the age of the household head (*G*) is an edge present condition, while good health (*H*) is negligible, and enough per capita family income (*J*) again plays a supporting role as an edge condition.

In Configuration 3, the diversity of household internet usage (*B*) and higher average family educational level (*I*) drive high-level educational investment. This indicates that good digital resources are very helpful for children's learning. Additionally, parents who are well-educated themselves are more likely to invest in their children's education. Other supporting conditions also contribute to high-level educational investment, but they are not the primary drivers.

For low-level rural educational investment, three configurations were identified. Configuration 1 shows that the absence of several key factors leads to low educational investment. Specifically, the presence of subjective risk attitude (*D*) makes families more conservative in their investment decisions, making them less willing to prone resources to their children's education. Additionally, the lack of essential supporting conditions such as the household head's good health (*H*), high average family educational level (*I*), and sufficient per capita family income (*J*) collectively weaken the family's ability to invest in education. Although basic internet usage (*A*) and social capital (*C*) are present, these edge conditions cannot compensate for the lack of core conditions. The unique coverage and raw coverage of configuration 1 are relatively high. This indicates that it effectively explains about 30% of low-level educational investment cases, with 67.4% of the sample cases only explained by this configuration.

Configuration 2 shows that while the family has some digital resources (*A*, *B*) and social capital (*C*), these supporting edge conditions are still insufficient to reverse the trend of low-level educational investment. The presence of subjective risk attitude (*D*) as a core condition influences the family's investment decisions, leading to more conservative educational spending. Additionally, the household head's age (*G*) is considered a negligible condition in this configuration, having little impact on the outcome. The unique coverage of configuration 2 is low, indicating significant overlap with other configurations and weaker independent explanatory power.

Configuration 3 differs from the others by emphasizing the household head's good health (*H*), yet the family still struggles to invest heavily in education due to the lack of other key resources. Specifically, the absence of diverse internet usage (*B*), subjective risk attitude (*D*), high average family educational level (*I*), and sufficient per capita family income (*J*) negatively impact educational investment. Although the family has basic internet usage (*A*), some social capital (*C*), and an

appropriate household head age (*G*), these edge conditions are not enough to drive more educational investment. Configuration 3 has the lowest raw coverage, showing its limited ability to explain low-level educational investment cases.

Table 6 illustrates the configurations for rural educational investment in the Western region. In this region, the consistency values of the six configurations leading to high-level rural educational investment are 0.851, 0.885, 0.856, 0.898, 0.860, and 0.871, all exceeding the 0.8 threshold. The overall consistency of these configurations is 0.817, indicating that the six high-level configurations can all be considered sufficient conditions influencing high-level rural educational investment. The overall coverage is 0.468, meaning these configurations can explain about 47% of the educational investment cases.

For low-level rural educational investment, the consistency values of the five configurations are also above 0.8. The data indicates that these configurations can explain about 42% of the cases.

Table 6. Sufficient configurations for rural educational investment under the digital divide of the western region.

	Configurations of western										
	1-high	**2-high**	**3-high**	**4-high**	**5-high**	**6-high**	**1-low**	**2-low**	**3-low**	**4-low**	**5-low**
A	·	·	·	·	·	·	·	·	·	·	·
B	●	●	●	●	●	●	⊗	⊗	·	·	⊗
C	·	·	·	·	·	·	·	·	·	·	·
D		⊗	●	⊗		⊗	·	·	⊗	⊗	⊗
E	⊗		⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
F	⊗	⊗	⊗		⊗	⊗	⊗	⊗	⊗	⊗	⊗
G	⊗	⊗	·	·		·		·	·	⊗	·
H	⊗	⊗	⊗	·	⊗		⊗		⊗	·	⊗
I		⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
J	●	●		●	●	●	⊗	⊗	⊗	⊗	·
K	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Raw coverage	0.280	0.222	0.215	0.191	0.333	0.221	0.174	0.141	0.164	0.139	0.079
Unique coverage	0.016	0.039	0.024	0.008	0.001	0.006	0.057	0.024	0.057	0.032	0.022
Consistency	0.851	0.885	0.856	0.898	0.860	0.871	0.892	0.861	0.917	0.907	0.889
Overall solution consistency	0.817						0.864				
Overall solution coverage	0.468						0.416				

Note: ● = core causal condition present; ⊗ = core causal condition absent; and ⊗ = edge condition; blank = dispensable.

In the Western region, six main configurations can explain why some families make high-level investments in their children's education. Configuration 1 shows that families with diverse internet resources (such as smartphones and computers) (*B*) and sufficient per capita family income (*J*) are more likely to invest more in education. Social capital (*C*) in these families also serves as a supportive condition, further promoting high educational investment. However, these are not decisive factors, as even if a family lacks certain conditions, such as a clear objective risk attitude (*E*), high satisfaction with public education (*F*), appropriate age of the

household head (*G*), good health (*H*), or a larger household size (*K*), these do not prevent them from making more investments in education. Configuration 1 has a raw coverage of 0.28, meaning about 28% of families meet the conditions of this path. However, the unique coverage is only 0.016, indicating significant overlap with other configurations. The result suggests that diverse internet resources and sufficient per capita family income are common patterns, and they are not the only explanatory factors.

Configuration 2 is very similar to Configuration 1, with a few differences. First, objective risk attitude (*E*) is considered a negligible condition, while the absence of a high average family educational level (*I*) and enough subjective risk attitude (*D*) are seen as edge conditions. This suggests that these families tend to rely more on objective facts and data rather than subjective judgment when making investment decisions. Configuration 2 has a unique coverage of 0.039, slightly higher than configuration 1, indicating it has greater distinctiveness in explaining high-level educational investment.

In Configuration 3, the core conditions change, with the diversity of internet usage (*B*) and the presence of subjective risk attitude (*D*) becoming core conditions. This shows that families not only have diverse internet resources but are also willing to take some risks in educational investment. Other edge present conditions include basic internet usage (*A*), some social capital (*C*), and an appropriate age of the household head (*G*), all of which further support high-level educational investment. Configuration 3 has a unique coverage of 0.024, indicating some overlap with other configurations.

Configuration 4 emphasizes that, in addition to diverse internet channels (*B*) and sufficient per capita family income (*J*), the appropriate age of the household head (*G*) and good health (*H*) also play edge present conditions. Specifically, household heads who are of an appropriate age and in good health are more likely to invest in education. This is because they tend to prioritize their children's future and seek to improve their family's social standing through education. Although Configuration 4 has a low unique coverage of 0.008, its high consistency of 0.898. This indicates a strong alignment between the conditions in this configuration and high-level educational investment.

Configuration 5 again highlights the importance of diverse internet usage (*B*) and sufficient per capita family income (*J*). However, unlike the other configurations, subjective risk attitude (*D*) and the age of the household head (*G*) do not influence educational investment decisions in this path. This indicates that these factors are not crucial here. Configuration 5 has a unique coverage of 0.001, showing almost no unique explanatory power, but a raw coverage of 0.333, meaning it can explain about 33.3% of high-level educational investment cases.

Configuration 6 is similar to the previous configurations, where diverse internet usage (*B*) and sufficient per capita family income (*J*) remain key factors for high-level educational investment. Other factors, such as some social capital (*C*) and the appropriate age of the household head (*G*), act as edge supportive conditions. Configuration 6 has a unique coverage of 0.006, indicating low distinctiveness. Its raw coverage of 0.221 shows it can explain 22% of high-level educational investment cases.

For low-level educational investment, Configuration 1 indicates that families with limited internet resources (lacking a smartphone or computer) (*B*), poor health of the household head (*H*), and low per capita family income (*J*) are likely to invest less in education. Although these families may have basic internet access (*A*) and some social capital (*C*), these edge conditions are not enough to compensate for the lack of other important conditions. The raw coverage of Configuration 1 is 0.174, showing it effectively explains 17.4% of cases in the low level of educational investment.

Configuration 2 is similar to Configuration 1, showing that families lacking sufficient internet resources (*B*) and sufficient per capita family income (*J*) tend to have lower educational investment. However, Configuration 2 also considers the supporting edge role of an appropriate age of the household head (*G*). Even so, the lack of other resources still leads to insufficient educational investment. Configuration 2 has a low unique coverage of 0.024, indicating its cases can also be explained by other paths.

Configuration 3 emphasizes the impact of the absence of subjective risk attitude (*D*), poor health of the household head (*H*), and low per capita family income (*J*). Even if these families have sufficient internet access (*A*, *B*), social capital (*C*), and the appropriate age of the household head (*G*), these edge conditions are not enough to offset the lack of other critical conditions. Configuration 3 has strong explanatory power in explaining certain unique cases.

Configuration 4 shows that if a family lacks the willingness to take subjective risks (*D*) and sufficient per capita family income (*J*), even with basic and diverse internet access (*A*, *B*), some social capital (*C*), and good health of the household head (*H*) as edge present conditions, their educational investment will still be low. In other words, although these families have some favorable conditions, the lack of risk-taking spirit and reasonable income planning prevents them from investing more in education. This configuration has a unique coverage of 0.032, indicating that 3% of cases are explained solely by this path.

Configuration 5 further emphasizes that if a family lacks diverse internet resources (*B*), willingness to take subjective risks (*D*), and the health of the household head (*H*), even if they have basic internet access (*A*), some social capital (*C*), appropriate age of the household head (*G*), and sufficient per capita family income (*J*) as edge present conditions, they are still likely to invest less in education. This suggests that digital resources, risk-taking attitudes, and health conditions greatly impact educational investment. If these conditions are lacking, other favorable conditions may not effectively drive low-level educational investment. Configuration 5 has the lowest unique coverage, indicating significant overlap with other paths and weaker explanatory power. This suggests that the educational investment decision patterns of these families are not unique and are similar to those explained by other paths.

In **Table 7**, the sufficient configurations for rural educational investment in the central region show five configurations that can explain high-level rural educational investment. Their consistency values are 0.864, 0.833, 0.816, 0.876, and 0.882, all above the threshold of 0.8. Overall consistency is 0.807, indicating these five configurations can be considered sufficient conditions influencing high-level rural

educational investment. The total coverage is 0.356, meaning these configurations can explain about 36% of high-level rural educational investment cases.

For low-level rural educational investment, there are also three configurations with consistency values above 0.8. The overall consistency is 0.843, with a coverage of 0.361. This indicates that these configurations can explain about 36% of low-level rural educational investment cases.

Table 7. Sufficient configurations for rural educational investment under the digital divide of the central region.

	Configurations of central							
	1-high	**2-high**	**3-high**	**4-high**	**5-high**	**1-low**	**2-low**	**3-low**
A	·	·	·	·	·	·	·	·
B	●	●	●	●	●	⊗	⊗	·
C	·	·	·	·	·	·	·	·
D		●	⊗	●	●	·	·	⊗
E	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
F	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
G	⊗	●	●	●			·	⊗
H	⊗		·	⊗	⊗	⊗		⊗
I	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
J	●	⊗	●		●	⊗	⊗	⊗
K	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Raw coverage	0.235	0.180	0.141	0.198	0.237	0.208	0.179	0.133
Unique coverage	0.035	0.016	0.031	0.001	0.002	0.049	0.020	0.133
Consistency	0.864	0.833	0.816	0.876	0.882	0.844	0.854	0.866
Overall solution consistency	0.807					0.843		
Overall solution coverage	0.356					0.361		

Note: ● = core causal condition present; ⊗ = core causal condition absent; and ⊗ = edge condition; blank = dispensable.

In the central region, five configurations can explain high-level educational investment by rural households. In Configuration 1, families with diverse internet resources (both smartphones and computers) (*B*) and sufficient per capita family income (*J*) are more likely to invest more in education. Basic conditions like internet usage (*A*) and social capital (*C*) also support their educational investment as edge present conditions. However, the absence of conditions like enough objective risk attitude (*E*), high satisfaction with public education (*F*), the appropriate household head's age (*G*), good health of the household head (*H*), high educational level of family members (*I*), or bigger household size (*K*) does not hinder their investment decisions. With a raw coverage of 0.235 and a unique coverage of 0.035, this configuration explains about 24% of the cases, but only 3% of cases are exclusively explained by this path.

In Configuration 2, families with diverse internet resources (*B*), a household head willing to take some risks in education (*D*), and an appropriate age of the household head (*G*) tend to invest more in education. Edge present conditions like

basic internet usage (*A*) and social capital (*C*) also contribute. Even without other conditions, these families still will make high-level educational investments. This configuration has a raw coverage of 0.18, meaning it effectively explains 18% of the cases. The unique coverage is 0.016, indicating that only 1.6% of cases are uniquely explained by this configuration.

Configuration 3 shows that when families have diverse internet resources (*B*), sufficient per capita family income (*J*), and an appropriate household head's age (*G*), they are more likely to invest heavily in education. Additionally, good basic internet usage (*A*), social capital (*C*), and the household head's health (*H*) also contribute to educational investment. Despite possibly lacking some conditions like a larger household size (*K*) or specific risk attitudes (*D*, *E*), these families still could make high-level educational investments.

Configuration 4 is similar to Configuration 2, but in this configuration, the household head's health (*H*) is an edge absent condition, and enough per capita family income (*K*) is less critical. The unique coverage for this path is very low, showing almost complete overlap with other paths.

In Configuration 5, high-level educational investment is driven by the diversity of internet resources (*B*), subjective risk attitude (*D*), and sufficient per capita family income (*J*). Basic internet usage (*A*) and social capital (*C*) also support this high-level investment as edge present conditions. The household head's age (*G*) is considered negligible in this path, and the absence of health (*H*) and smaller household size (*K*) does not significantly impact educational investment. Although the path has very low uniqueness, it can explain about 24% of the cases.

In the central region, three configurations explain low-level educational investment by households. In Configuration 1, families lacking diverse internet resources (no smartphone or computer) (*B*) and sufficient per capita family income (*J*) are more likely to make lower investments in education. Although these families may have basic internet resources (*A*), social capital (*C*), and a willingness to take subjective risks (*D*), these edge present conditions are insufficient to compensate for the lack of core conditions. As a result, the absence of other conditions (such as health, objective risk attitude, public education satisfaction, family members' educational level, and household size) does not significantly change the low level of educational investment. Configuration 1's raw coverage is 0.208, indicating it explains about 20.8% of low-level educational investment cases. The unique coverage of this path is 0.049, showing some uniqueness but also overlaps with other paths.

Configuration 2 is similar to Configuration 1, showing that when families lack sufficient internet resources (*B*) and per capita family income (*J*), their tendency to invest in education is lower. The difference is that Configuration 2 also considers the household head's age (*G*) as an edge supportive condition. Even with the appropriate age of the household head, the lack of other key resources still leads to insufficient educational investment. Configuration 2's raw coverage is 0.179, meaning it explains about 17.9% of low-level educational investment cases.

In Configuration 3, low-level educational investment is mainly influenced by the lack of subjective risk attitude (*D*), the inappropriate household head's age (*G*), and insufficient per capita family income (*J*). The absence of these core conditions

means that families may be more conservative and risk-averse in their educational investments, with the household head's age also not being conducive to boosting educational investment. Although these families have some internet resources (*A*, *B*) and social capital (*C*), these edge conditions are still insufficient to make up for the lack of other key factors, leading to an overall lower level of educational investment. Configuration 3's raw and unique coverage are both 0.133, meaning it explains about 13.3% of low-level educational investment cases, with 13.3% of cases being uniquely explained by this path. This shows high case-specific explanatory power.

In the Eastern region, as shown in **Table 8**, two configurations explain high-level rural educational investment. The consistency values for these two configurations are 0.791 and 0.830. The overall consistency is 0.782, but only the second configuration exceeds the 0.8 threshold, indicating that the second path is more effective in explaining high-level educational investment.

For low-level rural educational investment, the overall consistency is 0.8, with both paths showing consistency values above this threshold. This indicates that these paths reliably explain low-level educational investment. The overall coverage of 0.435 further demonstrates that 44% of low-level educational investment cases can be accounted for by these configurations.

Table 8. Sufficient configurations for rural educational investment under the digital divide of the eastern region.

	Configurations of eastern			
	1-high	**2-high**	**1-low**	**2-low**
A	·	·	·	·
B	·	·		⊗
C	·	·	·	·
D		·	·	·
E	⊗	⊗	⊗	⊗
F	⊗	⊗	⊗	⊗
G	·	⊗		·
H		⊗	⊗	
I	⊗		⊗	⊗
J	●	●	⊗	⊗
K	⊗	⊗	⊗	⊗
Raw coverage	0.269	0.196	0.412	0.185
Unique coverage	0.128	0.055	0.250	0.023
Consistency	0.791	0.830	0.811	0.806
Overall solution consistency	0.782		0.800	
Overall solution coverage	0.325		0.435	

Note: ● = core causal condition present; ⊗ = core causal condition absent; and ⊗ = edge condition; blank = dispensable.

In the Eastern region, two configurations explain why some families are willing to invest more in their children's education. In Configuration 1, sufficient per capita family income (*J*) plays a significant role in driving high-level educational

investment. Although internet resources (*A*, *B*), social capital (*C*), and an appropriate household head's age (*G*) may contribute to promoting educational investment, these are considered edge-supporting conditions. However, because the consistency of this configuration is below 0.8, it indicates that this path is not particularly stable or consistent in explaining educational investment decisions. In light of this, even if these conditions are present, families may not necessarily make high-level educational investments.

Configuration 2 also shows that sufficient per capita family income (*J*) is a key factor in promoting high-level educational investment. Unlike Configuration 1, however, Configuration 2 also identifies subjective risk attitude (*D*) as a supporting edge factor, indicating that these families are willing to take some risks in their educational investments. Additionally, the diversity of internet channels (*B*), basic internet access (*A*), and social capital (*C*) also contribute to educational investment as edge present conditions. Similar to Configuration 1, these families may lack certain conditions, such as objective risk attitude (*E*) and satisfaction with public education (*F*). However, these deficiencies do not significantly hinder their ability to make high-level educational investments. In other words, even if these families lack some advantages, they can still achieve high-level educational investment through a combination of other conditions.

Similarly, two configurations explain low-level educational investment by families. In Configuration 1, low educational investment is primarily due to insufficient per capita family income (*J*). Although the family may have basic internet resources (*A*), strong social capital (*C*), and a willingness to take some risks in education (*D*), these edge conditions are not enough to offset the impact of low per capita income. As a result, these families invest less in education. Additionally, the absence of other conditions, such as objective risk attitude (*E*), high satisfaction with public education (*F*), family's good health (*H*), family members' high educational level (*I*), and bigger household size (*K*), may further reduce their investment in education.

Configuration 2 is similar to Configuration 1. It shows that even if these families have basic internet resources (*A*), strong social capital (*C*), and some willingness to take risks (*D*), these edge factors are still insufficient to drive higher educational investment. Additionally, the household head's age (*G*) serves as a supporting condition in this path. This means that even if the household head is of an appropriate age, low per capita family income (*J*) remains the main barrier to educational investment. At the same time, the lack of other conditions, such as diverse internet channels (*B*), objective risk attitude (*E*), high satisfaction with public education (*F*), family members' high educational level (*I*), and bigger household size (*K*), does not significantly improve their level of educational investment.

4.3. Robustness checks

This study tested the robustness of the configurations in several ways. First, this study increased the frequency of high and low rural educational investment cases, and the resulting configurations were consistent with the original ones. Second, this study adjusted the consistency threshold from 0.80 to 0.90, and the recalculated

configurations remained consistent with the existing results. Therefore, the conclusions of this study are robust.

5. Conclusion

5.1. Discussion

The study reveals that the key factors influencing rural educational investment in China vary by region, but several factors are generally significant across all areas. First, internet usage is a crucial condition for high rural educational investment. The availability of smartphones or computers in the household will have a direct impact on educational investment, as digital devices provide rich educational resources and enhance children's learning abilities and motivation (Budiarti and Darmayanti, 2018). This study initially hypothesized that the presence of either a smartphone or a computer (*A*) would be sufficient to enhance educational investment in rural areas. However, the results indicate that the combined presence of both devices (*B*) is necessary to achieve a substantial impact. Variable *A* is often an edge condition across regions, variable *B* consistently appears as a core causal condition in high investment configurations, particularly in the Northeastern, Western, and Central regions. This suggests that combining both devices may provide more comprehensive access to educational resources, thereby exerting a stronger influence on educational investment. In contrast, in low investment configurations, *B*'s role varies, being either dispensable or absent, indicating that the mere presence of one device does not guarantee high investment. Second, family social capital plays a supportive role, offering economic and emotional support that helps families better cope with the challenges of educational investment (Warren et al., 2001). Additionally, the appropriate per capita income of the family is also of importance. Higher per capita income of the family is conducive to increased investment in education, especially in the Western, Eastern, and Central regions, as it allows more resources and attention for each child (Naoi et al., 2021).

The specific configuration of key factors varies across regions. In the Northeastern region, having both a computer and a smartphone in internet usage is the primary factor. When these conditions are met, social capital further assists in raising the level of investment in education. In the Central and Western regions, having both a computer and a smartphone in internet usage and higher per capita income of family primarily influence investment, with social capital as an auxiliary factor. In the Eastern region, higher per capita income of the family is the sole primary factor influencing high educational investment. Specifically, in the Northeastern region, every pathway shows that social capital plays a supportive role in educational investment under the digital divide. This indicates high levels of social networks and community participation. Although the economic level is slightly lower than in the Eastern region, strong social cohesion compensates for economic deficiencies (Molle, 2007). Families in the central and eastern regions typically have higher social capital due to their more mature economic development and are able to access more educational support through rich social networks and community resources (Inkeles, 2001). The Western region presents a more complex scenario. In remote rural areas, limited social networks hinder the acquisition and

sharing of information and resources (Wang et al., 2020). However, the mutual assistance spirit in ethnic minority communities and collectivist cultures also promotes educational investment to some extent (Dei, 2002).

5.2. Theoretical implications

This study makes several theoretical contributions. First, by using Necessary Condition Analysis (NCA) and Sufficient Condition Analysis (SCA), it reveals the key factors and configurations affecting high educational investment in rural China. This approach enhances understanding of rural educational investment, especially in the context of the digital divide. It highlights the importance and variability of internet usage, social capital, family size, and structure across different regions. This lays a foundation for research on achieving educational equity in the age of artificial intelligence.

Second, the study provides detailed and in-depth insights through regional analysis. It shows the different pathways and configurations of educational investment in the Northeastern, Eastern, Central, and Western regions. This revelation of regional differences offers a new perspective for existing educational investment theories, emphasizing the significant role of regional characteristics and socio-economic backgrounds in educational decision-making.

5.3. Practical implications

This study has practical implications for both policy-making and educational practice. First, the findings provide policymakers with a basis for creating precise and effective policies for educational investment and equity. Policymakers can target digital infrastructure development, digital literacy education, and the provision of necessary digital devices and resources based on regional specifics. For instance, in the Eastern region, efforts can focus on universal access to digital device adoption and high-quality digital education resources.

Additionally, the findings highlight the supportive role of social capital in educational investment, offering guidance for community organizations and NGOs. In economically disadvantaged areas, organizing community activities, strengthening community cohesion, and sharing resources can effectively compensate for economic deficiencies and boost educational investment levels. Educators and schools can also benefit by integrating digital technology into teaching, improving digital literacy among students and parents, and encouraging the use of the internet and digital devices to access educational resources. Meanwhile, schools should strengthen collaboration with communities through parent meetings and community events to enhance parental involvement in children's education.

5.4. Limitations

This study has several limitations. First, future research could consider other antecedent factors such as policy environment, school quality, infrastructure, and family cultural background (Fan et al., 2000; Li et al., 2020; Li and Qiu, 2018; Zhang, 2017). Additionally, factors like per capita collective assets in rural areas and major life events (e.g., marriage and job changes) may influence educational

investment decisions (Joo and Grable, 2004; Malone et al., 2010).

Second, this study uses data from a specific time period. Over time, changes in the socio-economic and policy environment in rural areas may affect key factors of educational investment (Below et al., 2012). Future research should consider analyses using long-term data to ensure the continued validity of the findings.

Furthermore, this study uses log-transformed and calibrated data to analyze educational investment, focusing on the pathways that lead to different levels of investment. However, the study does not adjust educational investment in relation to household income, which could limit the ability to fully understand the financial burden that educational spending places on lower-income families. However, it is supported by previous reports that show behavioral differences in educational spending across income levels (Liu et al., 2017). Research has demonstrated that low-income families tend to be more sensitive to academic performance and opportunity costs, typically increasing their educational investment only when their children demonstrate academic progress or as they advance through educational stages. In contrast, high-income families are less influenced by these factors, often investing in their children's education unconditionally, with a focus on quality rather than quantity. This disparity suggests that even without adjusting for income levels, absolute measures of educational investment, as used in this study, can still provide valuable insights into how different income groups prioritize education. Nonetheless, future research could benefit from incorporating income-adjusted measures to further understand the relative financial burden of educational investments across different income groups.

Finally, this study does not fully account for intra-regional heterogeneity. Within the same region in rural China, different counties and even villages may exhibit significant differences in economic development, cultural traditions, and social capital (Li et al., 2019; Yip et al., 2007). Future research should attempt more detailed regional subdivisions and analyses to reveal more nuanced differences and impact mechanisms.

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