Measurement and dynamic evolution of relative poverty in rural areas under the background of digitalization

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Abstract

Purpose – In the digital era, measuring rural relative poverty and exploring digitalization's role in poverty alleviation are critical for consolidating China's poverty-eradication achievements.

Design/methodology/approach – Based on the digitalization background, this paper constructs a rural relative poverty measurement system through the A-F double critical value method, measures the dynamic evolution of rural relative poverty in China from six dimensions: economy, education, health, living environment, psychological satisfaction and digitization level, and further analyzes the impact of rural digitalization development on rural relative poverty by constructing a fixed effect model.

Findings – (1) The relative poverty in rural China has been significantly alleviated; (2) the slow improvement of health poverty has become an important factor influencing the progress of rural relative poverty alleviation; (3) increased digitization has demonstrated significant efficacy in alleviating relative rural poverty, with regionally heterogeneous effects characterized by stronger impacts in western regions than eastern and central areas.

Originality/value – Therefore, it is necessary to establish a multidimensional relative poverty measurement standard which is more in line with the reality of rural China. More attention should be paid to the rural relative poverty in terms of health, and digital development should be utilized to improve their health level. The digital transformation of rural regions requires prioritized reinforcement, with a spatially adaptive development strategy tailored to regional disparities. Special emphasis should be placed on enhancing digital empowerment in western rural areas to ensure its targeted efficacy in driving sustainable rural revitalization.

Keywords Digitalization, Rural relative poverty, A-F double critical value method, Entropy method, Fixed-effect model

Paper type Research paper

1. Introduction

Since 2020, when China had built a moderately prosperous society in all respects and won the battle against poverty, China has eliminated absolute poverty. However, there are still some risks and factors in China's rural areas that may lead to relative poverty (Zou *et al.*, 2023). In the strategic layout of modernization efforts, greater attention should be paid to the problem of relative poverty in rural areas, and the results of the war against poverty should be constantly consolidated.

Relative poverty refers to a situation where, within a specific socio-economic context, the income an individual or a family earns from labor or other legitimate sources, although sufficient to meet their basic needs, is insufficient to enable them to attain the average living standard of a society and often falls far short of it. Members of society whose living conditions are below a certain percentage of the general standard of living are included in the category of relative poverty. Relative poverty not only focuses on income levels, but also emphasizes relative differences in the relative positions and quality of life of individuals or groups in society. Relative poverty measures issues such as unequal opportunities and restricted rights of different groups in a society, and is characterized by subjectivity and permanence, being

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relative and changing. Relative poverty typically affects a broader population, includes more dimensions of poverty, and is more risky than absolute poverty. A more in-depth study of relative poverty in rural areas is crucial to understanding the relative inadequacies of China's rural development as well as the variability of that development, and can provide valuable insights for sustained development in the post-Moderately Well-off Society period.

On the basis of consolidating the results of the war against poverty, it is still necessary to introduce some new forces and elements in order to further improve the quality and effectiveness of agricultural development, make the countryside a more suitable place to live and work, and enrich farmers. The report of the 19th CPC National Congress points out that since the implementation of the rural revitalization strategy, the state has strongly supported the broad application of emerging information and communication technologies in agriculture and rural development. The Outline of the Strategy for the Development of Digital Villages clearly emphasized that, as an important tool for promoting rural revitalization, digitalization is an indispensable part of the journey to build a digital China.

While reshaping social relations and empowering economic production, the wave of digitization has had a dual impact on social order and structural equality, creating development opportunities while exacerbating structural inequality (Yang *et al.*, 2025). Robinson *et al.* have argued that "the social landscape of the 21st century cannot be comprehensively analyzed without addressing digital inequality" (Robinson *et al.*, 2015). In the process of rural digitization, it is essential to capitalize on opportunities while mitigating risks of digital inequality. Rural areas in China confront multiple challenges, including inequality intensified by the digital divide, disruption of traditional industries, and employment displacement. The digital divide hinders a significant proportion of rural populations from accessing digital development dividends, while digital inequality is increasingly prominent (Wang, 2024). Digital technology dividends are disproportionately allocated to younger demographics and high-income groups, whereas disadvantaged farmers face systemic deprivation due to accelerated digital transformation, resulting in a self-perpetuating cycle of digital inequality. This differentiation manifests not only in the widening income gap but also in the profound restructuring of rural social relations, positioning digital exclusion as a critical factor contributing to relative poverty.

At the convergence of rural revitalization and the Digital China strategy, China's rural digital development confronts the dual paradox of technological empowerment and digital exclusion. To bridge the digital divide and advance inclusive digital development, the CPC Central Committee and the State Council have promulgated a series of strategic documents: the 2019 Digital Rural Development Strategy Outline established the framework for urban-rural digital integration; the 2021 14th Five-Year Plan for National Informatization reinforced the principle of digital inclusivity, mandating targeted digital literacy training programs for farmers, left-behind women, and vulnerable demographics; and the 2023 Digital China Development Strategy Outline institutionalized the eradication of the digital divide as a performance metric for local governance evaluations.Outline of the Digital Rural Development Strategy clarified the direction of integrating the digital development of urban and rural areas. Currently, the synergistic integration of the rural revitalization and Digital China Strategy has positioned rural regions as the epicenter of digital poverty alleviation. Balancing technological empowerment with digital exclusion not only directly impacts the sustainability of rural digitization but also shapes the strategic frameworks for mitigating relative poverty.

Against the background of the rapid development of digitalization in the new era, the formulation of standards for relative poverty and measures to combat relative poverty need to focus on adapting to the current national situation and be upgraded in various aspects, while ensuring that the poverty identification standards reflect the situation of relative inadequacy more comprehensively. Therefore, in the context of digitization, it is more necessary to construct a set of identification criteria and measurement system of relative poverty in line with the actual situation of rural China, and explore how digitization works to alleviate relative poverty, which is of great significance for consolidating the current achievements of China's poverty eradication, and for discussing the current situation of relative poverty in China and the history of poverty reduction. Therefore, based on the digitalization background, this paper constructs a rural relative poverty measurement system through the A-F double critical value method, measures the dynamic evolution of rural relative poverty in China from six dimensions: economy, education, health, living environment, psychological satisfaction, and digitization level, and further analyzes the impact of digitalization development on rural relative poverty by constructing a fixed effect model.

2. Literature review and theoretical analysis

2.1 Literature review on relative poverty and digitization

The concept of relative poverty was first introduced by Peter Townsend in 1979: individuals, families and groups in a population can be said to be in poverty when they lack sufficient resources to obtain the type typical of diet of the society to which they belong, to participate in socially recognized activities, or to have widely recognized living conditions and amenities. Their resources are grossly inferior to those at the disposal of the average individual or family and; in effect, they are excluded from ordinary patterns of life and activities (Townsend, 1979).

Amartya Sen defines relative poverty in terms of deprivation of viability, defining poverty as the lack of "basic viability" and arguing that poverty is not a matter of income at all, but rather a lack of "viability" to access certain basic material opportunities for survival (Sen, 2002). He defines viability as "the ability of people to do what they want to do and live the life they want to live". Absolute poverty and relative poverty are related yet very different. Absolute poverty, which measures poverty that is directly related to basic survival needs, is clear-cut and objective; relative poverty, which focuses more on unequal opportunities and restricted rights, is subjective, chronic, relative and variable. Compared with absolute poverty, relative poverty usually affects a wider population, covers more dimensions of poverty, and has a higher risk of poverty. In the process of alleviating relative poverty, it is necessary to face the challenges of sustained income increase, the problem of multidimensional poverty, the stimulation of endogenous motivation and the improvement of relevant institutions (Gao and Kong, 2020). The alleviation of relative poverty will be a long-term process and an important part of future poverty reduction efforts.

Digitalization has empowered China's all-round development transformation, and is a key force in transforming China from a large agricultural country into an agricultural powerhouse, revitalizing the countryside and moving towards common prosperity. As a core component of Digital China, digitalization has shown great potential in agriculture, rural areas and for farmers. The integration of digital technology into the development of agriculture is a necessary path for China to realize its development from a large agricultural country to an agricultural powerhouse. As a key component of Digital China, digital agriculture has great development potential. It is an important means of promoting the process of agricultural and rural informatization, and is an important measure for promoting rural revitalization and an inherent requirement for the high-quality development of rural economy (Zhang *et al.*, 2024b). The effective use of digital resources is an important way to consolidate the achievements of poverty alleviation and achieve the endogenous development of farmers (Wang and He, 2020). It can provide more entrepreneurial opportunities and development space for rural laborers, and promote the expansion of the scale, structural optimization, and quality improvement of the entrepreneurship of rural workers returning to their hometowns (Feng and Zhang, 2024). Breaking the economic plight of low – income rural residents and alleviating rural relative poverty are the key to achieving common prosperity for the people, as well as rural revitalization (Luan and Liu, 2021). And digital village construction can significantly promote farmers' income growth through infrastructure digitization, etc (Chen *et al.*, 2024). Moreover, the use of the Internet can enhance farmers' income-increasing ability and their desire for a better life, which is an important path for relative poverty governance (Nie *et al.*, 2024).

At present, a unified and generally recognized measurement standard has not yet been established in the research on the measurement of relative poverty at home and abroad, and the methods used in existing research to measure poverty mainly include the definition method, the income method, the Engel's coefficient method, the Gini coefficient method, the Extended Linear Consumption Model (ELES), and the A-F double-critical-value method based on the theory of viability. Among them, the definitional method, income method and Engel coefficient method are mainly used to measure absolute poverty. In 1901, Seebohm Rowntree established the foundational concept of absolute poverty in Poverty: A Study of Town Life, defining it through a quantitative threshold based on the minimum income required to meet physiological survival needs (Rowntree, 1902). This approach evolved in 1963 when American economist Mollie Orshansky systematized the modern definitional method by formulating the US official poverty line. Her methodology linked food expenditure proportions to total income, where households spending over one-third of their income on food were classified as impoverished (Orshansky, 1963). Concurrently, the income method was institutionalized in the 1960s. In 1964, the US Council of Economic Advisers (CEA) operationalized this approach by setting a single income threshold of 3,000 USD annually for households. Later, the World Bank expanded the scope of income-based measurement by introducing the "1 USD per day" international poverty line in 1990, which standardized cross-country comparisons. While both the definitional and income methods rely on monetary thresholds to demarcate poverty, the Engel coefficient method diverges by focusing on food expenditure as a proportion of total consumption, reflecting its roots in Engel's Law of consumption patterns. In 1857, German statistician Ernst Engel identified a negative correlation between household income and food expenditure proportion, now known as Engel's Law (Eatwell *et al.*, 1996). In 1955, the Food and Agriculture Organization of the United Nations (FAO) formalized the Engel coefficient, establishing a threshold of 60% as a criterion for poverty classification. The 1990 United Nations Human Development Report applied the Gini coefficient to analyze income inequality among impoverished populations. Unlike income-based approaches, the Gini coefficient quantifies societal income distribution inequality, integrating this dimension into poverty measurement. In 1973, economist Lluch introduced the Extended Linear Expenditure Model (ELES) to estimate basic needs expenditure via consumption functions (Lluch *et al.*, 1977). This model gained widespread adoption in developing countries post-1980 for poverty line determinations. ELES posits three fundamental assumptions derived from optimizing the linear expenditure system. These assumptions enable the model to shift poverty measurement from absolute to relative terms by analyzing consumption expenditure patterns. In 2007, Sabina Alkire and James Foster developed the A-F double critical value method based on capability theory (Alkire and Foster, 2010). This multidimensional poverty measurement framework employs two thresholds: a deprivation cutoff to identify unmet basic needs and a poverty cutoff to determine the minimum deprivation count for poverty classification. By integrating qualitative and quantitative data, this method allows flexible customization of dimensions, weights, and thresholds, making it adaptable to diverse socioeconomic contexts. Its multidimensional approach addresses limitations in unidimensional metrics like income or consumption expenditure, aligning with modern poverty research priorities (Wei and GE, 2020).

In the context of the digital era, following China's successful poverty alleviation campaign, establishing a refined multidimensional poverty measurement system is pivotal for mitigating rural relative poverty, enabling the implementation of targeted policy frameworks, and advancing high-quality rural economic development. Among the existing studies, there is relatively little literature on the dynamic measurement of rural relative poverty, and even less literature on the dynamic measurement of rural relative poverty from a digital perspective. Grounded in the capability approach theory, this study integrates rural residents' digital development levels into the evaluation framework. Aligning with the "Two Assurances and

Three Guarantees" policy objectives, we measure rural relative poverty across six dimensions: economy, education, health, living environment, psychological satisfaction, and digitization. A fixed-effects model is employed to analyze the relationship between rural digitalization and relative poverty, followed by actionable policy recommendations.

2.2 Theoretical basis and analysis

According to Amartya Sen's capability approach theory, an individual's "capability" is defined as the set of achievable functional activities that the individual can undertake. These functional activities encompass the basic necessities of daily life, such as food, clothing, housing, transportation, education, employment and social engagement. Consequently, the analysis of inequality should not be confined merely to income distribution; the relationship between income and substantive freedom is systematically influenced by various factors, including individual heterogeneity, environmental diversity, sociocultural norms, intra – household dynamics, and distributional differences (Sen, 2002). When measuring poverty, it is essential to consider multiple dimensions of relative poverty beyond just income.

With the development of digitalization, the popularization and application of the Internet can improve the living standards of rural residents by promoting knowledge sharing, among other means (Li *et al.*, 2023). On the one hand, at this stage, Internet use is gradually becoming an indispensable part of residents' daily life and penetrates into all aspects of farmers' daily life, including clothing, food, housing and transportation. The effective use of internet reflects, to a certain extent, the equality of rural residents' access to information and resources; on the other hand, in some areas, there are still some rural families without the Internet, and their access to new technologies is therefore limited, which leads to unequal information dissemination and information asymmetry (Marshall *et al.*, 2022). With the rapid development of digital technology, while it provides convenience and development for residents' lives, a digital divide has also emerged. It is therefore important to include digitalization in measuring the relative poverty of rural residents. Figure 1 demonstrates a pathway through which the level of rural digitization affects relative rural poverty.

The level of economic income is the primary and most direct indicator of poverty. The American economist Samuelson defines poverty in Economics as a condition in which people do not have enough income. Economic growth is a key factor in reducing poverty (Samuelson,

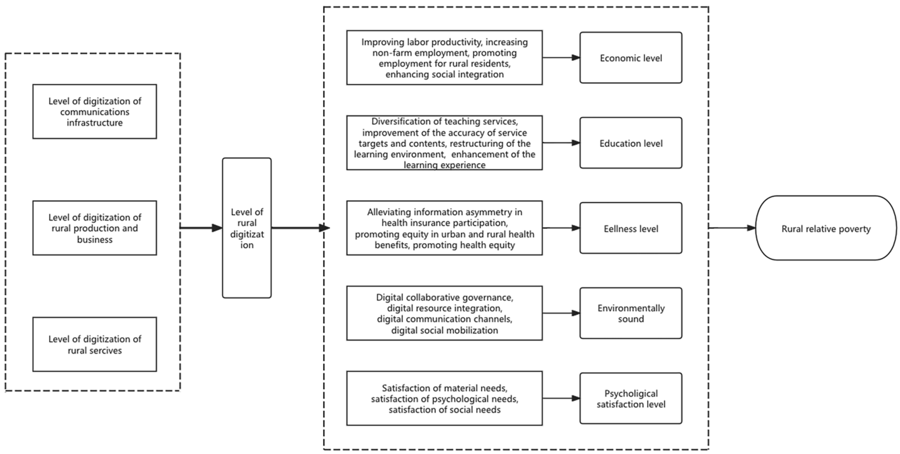

Figure 1. Pathways through which the level of rural digitization affects relative rural poverty. Source(s): Authors' own work

1952). Income is the primary means by which families acquire the necessities of life (e.g. food, shelter, clothing.). Without sufficient income, people are unable to meet these basic needs. The development of digitalization plays a significant role in increasing rural residents' income, and the digital economy can boost rural residents' income through channels such as improving labor productivity, increasing non-farm employment, promoting rural entrepreneurship, and enhancing social integration (Wang and Zhang, 2025; Li and Jiang, 2023).

Education plays a crucial role in promoting socio-economic equity and economic growth (Dominguez, 2021). Rather than relying solely on natural resources and manual labor, modern economic growth should focus on enhancing workers' intelligence and increasing the proportion of knowledge – based workers in production, thus optimizing the traditional allocation of factors of production (Zhang *et al.*, 2024a, b). One of the fundamental reasons for the backwardness of poor areas is the lack of human capital, manifested in workers' knowledge level, skill set and working ability. Education can enhance individuals' knowledge and skills, improve productivity, thereby increasing individual economic income and helping to reduce the income – distribution gap (Liu *et al.*, 2022). In the context of the education digitization strategy, the application of digital means to break down resource barriers and improve the quality of education is an important measure for poverty alleviation and prevention in less – developed region (Abrisham, 2011). The digitalization of education plays a crucial role in alleviating education poverty. It can help alleviate poverty in less – developed areas by providing diversified teaching services, improving the accuracy of services and content, reconstructing the learning environment and enhancing the learning experience (Li, 2024).

Health is one of the important dimensions of poverty. Health is the basis for an individual's access to social resources and self-development. A person's health directly affects his or her ability to work, productivity and economic income. Disease is one of the important factors that cause poverty among the rural poor (Jia *et al.*, 2022), and the return of poverty due to disease needs more attention and focus. Rural digital development can improve the willingness to participate in health insurance by alleviating the information asymmetry in health insurance participation, and at the same time, rural digital development also reduces the urban-rural health gap, which helps to realize the fairness of urban and rural health benefits and promote health equality (Alkire and Fang, 2019; Nasir *et al.*, 2024).

The improvement of the living environment plays an important role in reducing and eliminating poverty. The living environment not only affects the quality of life of the poor, but also influences the sustainable development and long-term economic prosperity of poor areas.; Improving the living environment can provide more development resources and opportunities can to poor areas, thus effectively reducing poverty (Saidatulakmal and Riaz, 2012; Astuti *et al.*, 2015). Digital development can enhance the living environment of rural residents through digital collaborative governance, digital-enabled resource integration, digital-enabled communication channels, and digital-enabled social mobilization (Polimeni and Iorgulescu, 2021).

The psychological dimension is also an important indicator of poverty. Mental health issues reduce employment opportunities, which consequently results in lower incomes. While improving the mental health of the population can contribute to economic growth. Psychological well-being and health significantly impact poverty (Snell-Rood and Carpenter-Song, 2018), influencing not only individuals' quality of life but also their economic status and social functioning. Alleviating psychological poverty is crucial for breaking the poverty cycle and promoting economic growth. The development of digital villages can enhance rural residents' well-being by meeting their material, psychological and social needs. The digitalization of rural economy, life and governance can boost rural residents' well-being of by increasing their income, promoting life convenience, and enhancing the government credibility (Wadsworth, 2018).

3. Research methods

3.1 Multi-dimensional relative poverty index

3.1.1 Delineation of the relative poverty line. First, assume that the group consists of n unrelated individuals. For any individual i within this group, its deprivation status is evaluated within a system encompassing a indicators ($a \geq 2$), such as the economic income level, physical health status, and living environment. Based on the A-F double critical value method, the single-dimension deprivation critical value, which is the threshold for determining whether an individual is in poverty in a single dimension, is set as m critical value. The critical value under dimension j is m_j. The overall deprivation critical value, used to identify whether an individual is in poverty across multiple dimensions, is set as k-critical value. If there is a deprivation matrix $D_a = [d_{ij}^a]$, then the expression for d_{ij}^a is:

$$d_{ij}^a = \begin{cases} \left(\frac{m_j - y_{ij}}{z_j}\right)^a, y_{ij} < z_j \\ 0, y_{ij} \geq z_j \end{cases} \tag{3-1}$$

When $a = 0$, $d_{ij}^a = 1$ or $d_{ij}^a = 0$. At this point, d_{ij}^a reflects the deprivation status of individual i in dimension j, that is, whether individual i is in a state of deprivation from dimension j's perspective. Therefore, when $a = 0$ there is:

$$d_{ij} = \begin{cases} 1, y_{ij} < z_j \\ 0, y_{ij} \geq z_j \end{cases} \tag{3-2}$$

In the above equation, when $d_{ij} = 1$, individual i is considered relatively poor in dimension j. When $d_{ij}^a = 0$, individual i is not considered relatively poor in dimension j.

Let s_i be the total weighted deprivation score of individual, and ω_{ij} be the weight of individual i in dimension j, respectively, then the expression for s_i is:

$$s_i = \sum_{j=1}^{a} \omega_{ij} d_{ij} \tag{3-3}$$

Finally, by comparing s_i with the k critical value, we can determine whether individual i is in a state of multidimensional relative poverty from an overall perspective. When $s_i \geq k$, individual i can be considered to be in a state of multidimensional relative poverty overall; when $s_i < k$, individual i is not considered to be in a state of multidimensional relative poverty overall.

3.1.2 Calculation of the relative poverty index. Let the total number of multidimensional relatively poor individuals be p, and the average number of deprived dimensions among the relatively poor be E. Then, the expressions for the relative poverty incidence, R, and the average degree of deprivation among the relatively poor, E, can be derived as follows:

$$R = p/n \tag{3-4}$$

$$E = \frac{1}{p} \sum_{i=1}^{n} s_i = \frac{1}{p} \sum_{i=1}^{p} \sum_{j=1}^{a} \omega_j d_{ij}^a \tag{3-5}$$

The Multidimensional Relative Poverty Index, represented as I, reflects the average degree of deprivation of the entire population, I can be expressed as:

$$I = \frac{1}{n}\sum_{i=1}^{n} s_i = \frac{p}{n} \times \frac{1}{p}\sum_{i=1}^{n} s_i = R \times E \tag{3-6}$$

Consequently, the multidimensional relative poverty index can be decomposed into the product of poverty incidence and multidimensional poverty depth (Fang and Zhou, 2021).

3.1.3 Decomposability of the relative poverty index. In the multidimensional context, the relative poverty index satisfies dimensional decomposability. That is, the overall multidimensional relative poverty index of individual *i* can be represented as the sum of its relative poverty indices in each dimension. The relative poverty index contribution rate RC_j of dimension *j* can be expressed as (Alkire and Foster, 2010):

$$RC_j = \frac{I_j}{I} \tag{3-7}$$

3.2 Entropy method

The entropy method is a multi-indicator comprehensive evaluation approach primarily used to determine the weight of each indicator. It is grounded in the entropy concept from information theory, which measures the degree of dispersion and the information content of the indicators. The specific steps are as follows:

Construct the evaluation matrix. Assuming there are *m* evaluation objects and *n* evaluation indicators. Construct the $m \times n$ matrix *X*, where X_{ij} represents the value of the *i*-th evaluation object on the *j*-th indicator.

Data standardization.

Positive Indicator:

$$X'_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} \tag{3-8}$$

Negative Indicator:

$$X'_{ij} = \frac{\max(X_{ij}) - X_{ij}}{\max(X_{ij}) - \min(X_{ij})} \tag{3-9}$$

Calculate the share of indicator *j* in year *i*:

$$P_{ij} = \frac{X'_{ij}}{\sum_{i=1}^{m} X'_{ij}} \tag{3-10}$$

Calculate the information entropy:

$$e_j = \frac{-\sum_{i=1}^{m} P_{ij} \ln P_{ij}}{\ln(m)} \tag{3-11}$$

Calculate the coefficient of variation:

$$d_j = 1 - t_j \tag{3-12}$$

Determine the weights:

$$W_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{3-13}$$

Calculate the combined score:

$$D_i = \sum_{i=1}^{m} W_j X'_{ij} \tag{3-14}$$

3.3 Benchmark regression models

Based on the panel data of rural digital development level and rural relative poverty index, the following benchmark regression model is constructed:

$$I_{it} = \beta_0 + \beta_1 \ln DL_{it} + \beta_2 control_{it} + \alpha_i + \lambda_t + \mu_{it} \tag{3-15}$$

where I_{it} represents the relative poverty status, DL_{it} represents the level of rural digitization, $control_{it}$ represents the control variables, including the urbanization level, the economic development level, the transportation facilities level, and the human capital level. α_i represents the fixed effect of the i- th household, λ_t represents time fixed effect, and μ_{it} is the stochastic error term.

4. Analysis of the dynamic measurement of relative poverty in rural China

4.1 Sources of data

The data employed in this paper for measuring relative poverty are derived from six rounds of the CFPS surveys conducted in 2010, 2012, 2014, 2016, 2018 and 2020. The CFPS survey area encompasses 25 provinces in China, with the total population in these areas accounting for 95% of the country's total population. The data collected cover the status and changes in the economic and educational conditions of individuals, families, and communities, rendering the survey sample comprehensive and representative. The data related to the digitization level are primarily from the China Statistical Yearbook, China Rural Statistical Yearbook, National Bureau of Statistics, and the research report of Ali Research Institute, among others, in which there are a small number of missing values, which are filled using interpolation methods.

4.2 Selection of multidimensional rural relative poverty indicators

Based on the CFPS data from 2010, 2012, 2014, 2016, 2018 and 2020, referring to the relevant literature, and combining the goal of "Two Assurances and Three Guarantees" goal, we measure rural relative poverty across five dimensions: economy (household income level), education (educational attainment, Expenditure level on education), health (health status, basic medical insurance. medical burden), living environment (housing, cooking fuel, drinking water), and psychological satisfaction level (satisfaction with life, well-being, confidence level), We constructed an indicator system to measure rural relative poverty from these five dimensions. By referring to the construction methodology of the UNDP Multidimensional Poverty Index, equal weights were assigned to each of the five primary and twelve secondary indicators. In the context of digitization, digitization level indicators (including Internet usage) were added to the original five first-level indicators, resulting in a total of six dimensions, consisting of six first-level indicators and thirteen second-level indicators. The specific indicator settings and weights for both scenarios are presented in Table 1.

Table 1. Indicators for measuring relative rural poverty

Level 1 indicators	Level 2 indicators	Deprivation thresholds	Corresponding questions on the CFPS questionnaire	Weighting (excluding digitization level dimension)	Weighting (including digitization level dimension)
Economic level	Household income level	Assign a value of 1 if the total household income is less than 40% of the median, otherwise 0	QK6A	1/5	1/6
Education level	Educational attainment	The highest level of education of all members of the family is elementary school or illiterate or semi-illiterate is assigned a value of 1, otherwise it is 0	QC1	1/10	1/12
	Expenditure level on education	Household expenditure on education is assigned a value of 1 if it accounts for more than 50% of consumption expenditure, and 0 otherwise	FH404	1/10	1/12
Health level	Health status	Assign a value of 1 if a family member has rated himself/herself as unhealthy, and 0 otherwise	QP3	1/15	1/18
	Basic medical Insurance	Any member of the household who does not have health insurance is assigned a value of 1, otherwise it is 0	QJ3	1/15	1/18
	Medical burden	Household health care expenditure is assigned a value of 1 if it is more than 50% of consumption expenditure, and 0 otherwise	FH402	1/15	1/18
Living environment	Housing	Assigned a value of 1 if the family has no ownership of the house, and 0 otherwise	FD1	1/15	1/18
	Cooking fuel	Assigns a value of 1 if the cooking fuel is firewood, coal and others, and 0 otherwise	FB2	1/15	1/18
	Drinking water	Household cooking water that is not tap water, bottled water, purified water or filtered water is assigned a value of 1 (not clean water), otherwise it is 0	FB1	1/15	1/18

(*continued*)

Table 1. Continued

Level 1 indicators	Level 2 indicators	Deprivation thresholds	Corresponding questions on the CFPS questionnaire	Weighting (excluding digitization level dimension)	Weighting (including digitization level dimension)
Psychological satisfaction level	Satisfaction with life	Any member of the family is very dissatisfied with life assigns a value of 1, otherwise 0	QM403	1/15	1/18
	Well-being	Any member of the family considers himself/herself to be very unfortunate is assigned a value of 1, otherwise it is 0	QK802	1/15	1/18
	Confidence level	Any member of the family who is not confident about the future is assigned a value of 1, otherwise it is 0	QK803	1/15	1/18
Digitization level	Internet usage	No member of the household uses the Internet (computer or cell phone access) assigned a value of 1, otherwise 0	KU2		1/6

Source(s): Authors' own work

In this paper, we use the "Rural-Urban Classification Based on NBS Data" in the CFPS data as a benchmark. We exclude the data categorized as urban and filter the data categorized as rural to obtain the data of rural individuals and households.

In the process of establishing and measuring the indicators of rural multidimensional relative poverty, indicators at the individual and household levels are involved, with the indicators of economic level and living environment identifying relative poverty at the household level, and the indicators of education level, health level, psychological satisfaction level and digitalization level identifying relative poverty at the individual level. Considering that China's population exhibits significant characteristics of family members living together, this study selects the family as the most basic object of investigation. In the process of data processing, 2010 was selected as the base year. Based on the family number in 2010, the data from the adult database was matched with the family database. Finally, the samples meeting the requirements were obtained, and the number of valid data entries was 2,098.

4.3 Measurement of the multidimensional relative rural poverty index and results analysis

In this paper, referring to the relevant literature, the k critical values of 0.33 and 0.5 were taken. The poverty incidence, poverty deprivation intensity, and multidimensional poverty index were calculated to measure multidimensional relative poverty in rural areas under the two scenarios for the years 2010, 2012, 2014, 2016, 2018, and 2020, respectively, from the perspective of including the dimension of digitization level and excluding the dimension of digitization level. The measurements results are shown in Table 2 and Table 3.

Based on the measurement results in Table 2, the overall improvement trend of rural China's multidimensional relative poverty is relatively obvious, with the overall relative

Table 2. Measurement results of indicators related to relative rural poverty (excluding the digitization level dimension)

k threshold	Measurement indicators	2010	2012	2014	2016	2018	2020
0.33	Incidence of poverty	0.3070	0.2731	0.2131	0.2059	0.2150	0.1954
	Intensity of poverty deprivation	0.4400	0.4610	0.4415	0.4356	0.4371	0.4253
	Multidimensional poverty index	0.1351	0.1259	0.0941	0.0897	0.0940	0.0831
0.5	Incidence of poverty	0.0491	0.0439	0.0329	0.0319	0.0338	0.0234
	Intensity of poverty deprivation	0.5909	0.5992	0.5995	0.5891	0.5887	0.5864
	Multidimensional poverty index	0.0290	0.0263	0.0197	0.0188	0.0199	0.0137

Source(s): Authors' own work

Table 3. Results of the measurement of indicators related to relative rural poverty (including the digitization level dimension)

k threshold	Measurement indicators	2010	2012	2014	2016	2018	2020
0.33	Incidence of poverty	0.5405	0.4438	0.3704	0.2974	0.2703	0.1978
	Intensity of poverty deprivation	0.4569	0.4754	0.4509	0.4563	0.4563	0.2924
	Multidimensional poverty index	0.2470	0.2109	0.1670	0.1357	0.1233	0.0897
0.5	Incidence of poverty	0.1663	0.1616	0.1034	0.0839	0.0834	0.0605
	Intensity of poverty deprivation	0.5822	0.5925	0.5832	0.5851	0.5821	0.5759
	Multidimensional poverty index	0.0969	0.0957	0.0603	0.0491	0.0486	0.0349

Source(s): Authors' own work

poverty level showing a downward trend. When $k = 0.33$, the multidimensional relative poverty level decreases from 0.1351 in 2010 to 0.0831 in 2020, a decrease of approximately 48%. When $k = 0.5$, the multidimensional relative poverty level decreases by about 53% from 2010 to 2020, indicating a significant improvement in rural China's relative poverty situation.

Moreover, from 2010 to 2020, the relative poverty incidence among China's rural population has decreased significantly. When not considering the digitization level, the relative poverty incidence rate was 30.7% in 2010 with a value of k of 0.33, and then decreases to 19.5% in 2020; with a value of k of 0.5, the relative poverty incidence rate was 4.9% in 2010, and then decreases to 2.3% in 2020. Evidently, the poverty incidence declines significantly at both k values of 0.33 and 0.5, indicating a significant decline in the number of poor people in rural China. This also implies that the effective implementation of China's targeted poverty alleviation policies has led to a significant improvement in the quality of life of rural residents.

From 2010 to 2020, the intensity of poverty deprivation remains relatively constant. When $k = 0.33$, the intensity of poverty deprivation decreases by only about 3.3% from 2010 to 2020. When $k = 0.5$, the intensity of poverty deprivation decreases by only about 0.1% from 2010 to 2020, and the intensity of poverty deprivation remains at a very high level.

Based on the above analysis, the decline in rural China's overall multidimensional relative poverty index is mainly attributed to the decrease in the relative poverty incidence, as the intensity of poverty deprivation contributes little to the decline of this index. Therefore, despite the great success of China's targeted poverty alleviation work in recent years, the relative poverty incidence in rural areas is as high as 19.5% in 2020 when $k = 0.33$, and the intensity of poverty deprivation remains at a relatively high level. From a multidimensional perspective, the relative poverty situation in rural China still warrants attention.

Based on the results in Table 3, when the digitization – level dimension is added, the improvement trend of overall rural multidimensional poverty in China is more pronounced than when this dimension is not included. With values of both 0.33 and 0.5, the multidimensional poverty level decreases by nearly 64% from 2010 to 2020. The poverty incidence also declines by almost 64% from 2010 to 2020 for both $k = 0.33$ and $k = 0.5$. The decrease in the poverty – deprivation intensity is insignificant. This indicates, on the one hand, the popularity and development of digitization in rural China. On the other hand, it shows the positive role of digitization in reducing the poverty incidence and alleviating relative poverty in rural China.

4.4 Decomposition of the multidimensional rural relative poverty index

Multidimensional relative poverty is decomposed by dimensions to further analyze the differences and changes in the dimensions of rural multidimensional relative poverty. The results of the decomposition measurements are presented in Table 4 and Table 5.

Analyzing the relative poverty index and the contribution rate of each dimension in Table 4 reveals significant differences in the contribution rates of different dimensions to overall relative poverty and their change trends. First, a specific analysis of different dimensions shows that the living environment, economic level, and education level dimensions have higher contribution rates to the rural multidimensional relative poverty index. In contrast, the health level and psychological satisfaction level dimensions have relatively minor impacts on this index. Secondly, an analysis of the poverty contribution rate of each dimension and the dynamic trend of the index shows that from 2010 to 2020, the contribution rate of the living environment dimension shows an obvious decreasing trend. However, for the health level dimension, although the relative poverty index decomposed by this dimension has decreased, the relative poverty contribution rate of the index has shown an increasing trend. This indicates that the improvement of the health of Chinese rural residents lags behind that of living standards and other dimensions. Thus, the relative poverty of Chinese rural residents in the health level dimension requires more attention.

Based on Table 5, after adding the digitization – level dimension, from 2010 to 2020, the contribution rate of the digitization level shows a significant decrease, the contribution rate of the health level shows a significant increase, and changes in other dimensions are relatively insignificant. This indicates that the digitization level of the surveyed population has

Table 4. Results of the decomposition of the dimensions of relative rural poverty ($k = 0.5$) (excluding the digitization level dimension)

Year	Multidimensional relative poverty index	Relative poverty contribution rate, unidimensional relative poverty index				
		Income level	Education level	Health level	Environmentally sound	Psychological satisfaction level
2010	0.0290	23.40%	20.60%	14.56%	34.63%	6.81%
		0.0068	0.006	0.0042	0.01	0.002
2012	0.0263	21.68%	28.47%	16.74%	25.75%	7.36%
		0.0057	0.0075	0.0044	0.0068	0.0019
2014	0.0197	22.02%	21.58%	18.71%	33.15%	4.55%
		0.0043	0.0043	0.0037	0.0065	0.0009
2016	0.0188	18.44%	23.47%	20.60%	31.88%	5.61%
		0.0035	0.0044	0.0039	0.006	0.0011
2018	0.0199	19.38%	21.04%	26.65%	28.91%	4.02%
		0.0039	0.0042	0.0053	0.0058	0.0008
2020	0.0137	22.71%	17.23%	28.64%	27.77%	3.64%
		0.0031	0.0024	0.0039	0.0038	0.0005

Source(s): Authors' own work

Table 5. Results of the decomposition of the dimensions of relative rural poverty ($k = 0.5$) (including the digitization level dimension)

Year	Multidimensional relative poverty index	Relative poverty contribution rate, unidimensional relative poverty index					
		Income level	Education level	Health level	Environmentally sound	Psychological satisfaction level	Digitization level
2010	0.0969	14.44%	12.71%	8.98%	21.37%	4.20%	38.30%
		0.014	0.0123	0.0087	0.0207	0.0041	0.0371
2012	0.0957	16.76%	22.01%	12.94%	19.91%	5.69%	22.69%
		0.016	0.0211	0.0124	0.0191	0.0054	0.0217
2014	0.0603	13.87%	13.60%	11.79%	20.89%	2.87%	36.99%
		0.0084	0.0082	0.0071	0.0126	0.0017	0.0223
2016	0.0491	12.65%	16.10%	14.13%	21.87%	3.85%	31.39%
		0.0062	0.0079	0.0069	0.0107	0.0019	0.0154
2018	0.0486	14.24%	15.46%	19.59%	21.24%	2.95%	26.51%
		0.0069	0.0075	0.0095	0.0103	0.0014	0.0129
2020	0.0349	18.29%	13.88%	23.06%	22.36%	2.93%	19.49%
		0.0064	0.0048	0.008	0.0078	0.001	0.0068

Source(s): Authors' own work

significantly improved, while the improvement of the physical health level of Chinese rural residents in relation to poverty is still relatively slow.

4.5 Analysis of the impact of digitization level on rural multidimensional relative poverty

4.5.1 Comprehensive evaluation of rural digitization level. Based on the theoretical connotation of digital rural development and combined with the related research results of Wang and Li (2024), Kong *et al.* (2024), Yi *et al*. (2024) and Wang *et al.* (2024), this paper constructs an evaluation index system for China's digital rural development level from three dimensions: the digitization level of communications infrastructure, the digitalization level of rural production and business, and the digitalization level of rural services. The system is shown in Table 6.

The comprehensive scores of the rural digitalization development levels of 31 provinces were calculated using the entropy method, as presented in Table 7. Based on the results, the digitization level of each province shows a year – by – year rising trend; economically developed regions such as Beijing, Shanghai, Zhejiang, Shandong and Jiangsu have a high level of rural digital development; regions such as Qinghai, Tibet Autonomous Region, and Xinjiang Uygur Autonomous Region have a low level of rural digital development due to their

Table 6. System of indicators for evaluating the development of rural digitization levels

Level 1 indicators	Level 2 indicators	Description of indicators	Attribute
Level of digitization of communications infrastructure	Internet penetration rate	Rural Internet broadband access subscribers (10,000)/rural population	Positive
	Smartphone penetration rate	Average year-end cell phone ownership per 100 rural households (units)	Positive
	Computer penetration rate	Average number of computers per 100 rural households at the end of the year (units)	Positive
	Radio and television penetration rate	Number of rural cable radio and television subscribers as a proportion of total number of households (%)	Positive
	Number of agrometeorological observation stations	Number of operational agrometeorological observation stations (number)	Positive
Level of digitization of rural production and business	Percentage of Internet commerce	Number of Taobao villages/number of administrative villages (%)	Positive
	Number of enterprise websites	Websites per 100 businesses	Positive
	Active participation of enterprises in e-commerce	Share of enterprises with e-commerce trading activities (%)	Positive
	Fixed investment in the socio-digital industry	Number of legal entities in the information transmission, software and information technology services industry (units)	Positive
	Level of digital finance	Peking University Digital Inclusive Finance Index	Positive
Level of digitization of rural services	Digital Talent Service Workforce	Agricultural technology professionals and technicians in public economic enterprises and institutions	Positive
	Level of consumption of digital services	Per capita transportation and communication consumption expenditure of rural households (yuan)	Positive
	Proportion of courier deliveries to villages	Proportion of administrative villages with postal service (%)	Positive

Source(s): Authors' own work

Table 7. Composite score for the level of digital development of villages

Province	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Anhui	0.22	0.23	0.27	0.31	0.34	0.38	0.41	0.43	0.48	0.51	0.52
Beijing	0.30	0.38	0.42	0.49	0.51	0.55	0.57	0.60	0.63	0.64	0.66
Fujian	0.32	0.36	0.37	0.39	0.41	0.44	0.46	0.48	0.53	0.57	0.57
Gansu	0.20	0.22	0.25	0.28	0.32	0.35	0.38	0.38	0.44	0.45	0.46
Guangdong	0.29	0.33	0.36	0.40	0.41	0.44	0.46	0.51	0.60	0.63	0.64
Guangxi Zhuang Autonomous Region	0.24	0.26	0.28	0.31	0.33	0.34	0.36	0.37	0.45	0.47	0.48
Guizhou	0.14	0.17	0.20	0.23	0.29	0.33	0.37	0.40	0.45	0.48	0.49
Hainan	0.19	0.21	0.25	0.29	0.33	0.37	0.39	0.40	0.43	0.43	0.44
Hebei	0.26	0.28	0.31	0.35	0.37	0.40	0.43	0.45	0.49	0.51	0.52
Henan	0.21	0.25	0.27	0.31	0.33	0.37	0.40	0.41	0.46	0.47	0.48
Heilongjiang	0.24	0.26	0.29	0.32	0.34	0.37	0.39	0.40	0.46	0.47	0.47
Hubei	0.26	0.28	0.31	0.35	0.36	0.40	0.42	0.43	0.50	0.52	0.55
Hunan	0.22	0.25	0.28	0.32	0.34	0.38	0.42	0.44	0.50	0.51	0.52
Jilin	0.27	0.30	0.32	0.35	0.36	0.39	0.39	0.40	0.45	0.46	0.48
Jiangsu	0.36	0.39	0.43	0.46	0.49	0.54	0.55	0.59	0.60	0.64	0.64
Jiangxi	0.26	0.29	0.32	0.34	0.37	0.39	0.41	0.44	0.49	0.49	0.50
Liaoning	0.20	0.23	0.25	0.30	0.33	0.38	0.41	0.42	0.43	0.43	0.43
Inner Mongolia Autonomous Region	0.23	0.25	0.27	0.29	0.34	0.36	0.33	0.40	0.45	0.45	0.46
Ningxia Hui Autonomous Region	0.20	0.22	0.27	0.30	0.32	0.34	0.33	0.37	0.40	0.41	0.42
Qinghai	0.09	0.10	0.13	0.17	0.27	0.32	0.36	0.36	0.39	0.40	0.42
Shandong	0.32	0.36	0.38	0.41	0.42	0.46	0.50	0.52	0.59	0.61	0.63
Shanxi	0.22	0.24	0.27	0.30	0.32	0.35	0.37	0.38	0.39	0.40	0.41
Shaanxi	0.24	0.26	0.30	0.32	0.37	0.40	0.43	0.45	0.49	0.49	0.51
Shanghai	0.28	0.31	0.35	0.39	0.42	0.46	0.45	0.46	0.46	0.47	0.46
Sichuan	0.25	0.28	0.31	0.34	0.37	0.41	0.44	0.46	0.52	0.54	0.55
Tianjin	0.20	0.22	0.26	0.31	0.34	0.38	0.41	0.44	0.43	0.44	0.44
Tibet Autonomous Region	0.10	0.12	0.14	0.18	0.22	0.27	0.30	0.30	0.36	0.37	0.36
Xinjiang Uygur Autonomous Region	0.19	0.22	0.25	0.27	0.30	0.32	0.34	0.34	0.41	0.42	0.42
Yunnan	0.23	0.25	0.28	0.31	0.34	0.37	0.40	0.41	0.48	0.49	0.50
Zhejiang	0.36	0.41	0.44	0.47	0.49	0.54	0.57	0.60	0.63	0.65	0.67
Chongqing	0.20	0.16	0.25	0.28	0.31	0.34	0.35	0.39	0.42	0.44	0.47

Source(s): Authors' own work

relatively backward economies; and some populous provinces such as Guangdong and Sichuan have a medium level of rural digital development.

4.5.2 Variable selection. In this paper, the rural relative poverty index is selected as the dependent variable, and the level of rural digital development is selected as the independent variable. In order to control the influence of factors other than the core explanatory variables, and referring to the relevant research results of Wang and Li (2024), Kong *et al.* (2024), Yi *et al.* (2024) and Wang *et al.* (2024), the following are selected as control variables: urbanization level (expressed as the ratio of urban population to total population), economic development level (expressed as the per capita GDP), transportation facilities level (expressed as road mileage), and the human capital level (expressed as the number of students enrolled in general higher education institutions), as shown in Table 8. Table 9 shows the descriptive statistics of the variables.

4.5.3 Regression model establishment. To empirically analyze the alleviating effect of rural digital development level on rural relative poverty, this paper constructs the following fixed-effects model:

$$I_{it} = \beta_0 + \beta_1 \ln DL_{it} + \beta_2 \ln UL_{1it} + \beta_3 \ln EDL_{2it} + \beta_4 \ln TL_{3it} + \beta_5 \ln HCL_{4it} + \alpha_i + \lambda_t + \mu_{it} \quad (4\text{-}1)$$

where I_{it} represents the relative poverty status, DL_{it} represents the level of rural digitization, UL_{it}, EDL_{it}, TL_{it}, HCL_{it} represent urbanization level, economic development level, transportation level and human capital level, respectively, α_i represents the fixed effect of the i – th household, λ_t represents time fixed effect, and μ_{it} is the stochastic error term.

4.5.4 Regression results and analysis. After conducting the Hausman test to select the fixed – effect model, the results of the fixed – effect model measuring the impact of digital development on rural relative poverty are obtained, as shown in Table 10. Column (1) estimates the univariate relationship between digitization level and relative poverty, Column (2) incorporates control variables, Column (3) adds household fixed effects, and Column (4) includes both household and year fixed effects. The regression results consistently show a statistically significant negative association between digitization level and relative poverty regardless of the inclusion of control variables and fixing for household and year. Specifically, after incorporating control variables, the two-way fixed effects model (Column 4), the coefficient of digitization level on rural relative

Table 8. Model variables and descriptions

Variable types	Variable names	Variable symbols	Measurement methods	Units
Explained Variable	Rural relative poverty	I	A-F double critical value method	N/A
Explanatory Variable	Digitalization level	DL	Entropy method	N/A
Control Variables	Urbanization level	UL	Urban population/Total population	%
	Economic development level	EDL	Per capita GDP	Yuan/ person
	Transportation facilities level	TL	Road mileage	10,000 km
	Human capital level	HCL	Number of students Enrolled in general higher education	10,000 people

Source(s): Data from CFPS(2010,2012,2014,2016,2018,2020) and NBS

Table 9. Descriptive statistics of variables

Variables	Units	Obs	Mean	Std. dev	Min	Max
I	N/A	12,510	0.26	0.17	0.00	0.86
DL	N/A	12,510	0.38	0.11	0.14	0.67
UL	%	12,510	52.66	10.66	33.80	89.58
EDL	Yuan/person	12,510	40965.56	17788.03	12882.00	156803.00
TL	10,000 km	12,510	17.96	6.13	1.20	33.71
HCL	10,000 people	12,510	106.12	55.24	32.33	249.22

Source(s): Data from CFPS(2010,2012,2014,2016,2018,2020) and NBS

Table 10. Fixed effects model results

Variables	I (1)	(2)	(3)	(4)
lnDL	−0.150***	−0.151***	−0.148***	−0.0983***
	(0.00371)	(0.00386)	(0.00423)	(0.0209)
lnUL		0.022	−0.0784*	−0.0538
		(0.0288)	(0.0415)	(0.043)
LnEDL		−0.0252**	−0.00362	−0.0067
		(0.0124)	(0.0209)	(0.0208)
lnTL		0.0186	−0.03	−0.0549
		(0.0114)	(0.0408)	(0.0415)
lnHCL		−0.000305	0.0402*	0.0544**
		(0.00873)	(0.0221)	(0.0227)
Constant	0.103***	0.330**	−0.00604	0.132
	(0.00475)	(0.134)	(0.182)	(0.188)
Household	NO	NO	YES	YES
Year	NO	NO	NO	YES
Observations	12,510	12,510	12,510	12,510
R-squared	0.1351	0.1359	0.1366	0.1494

Note(s): ① Values in brackets under the regression coefficients are standard errors; ② *, **, *** represent 10%, 5%, and 1% significance levels, respectively
Source(s): Authors' own work

poverty remains negative and significant at the 1% confidence level. This finding suggests that advances in digitization are associated with measurable improvements in the alleviation of rural relative poverty and that digital development has a positive effect on the alleviation of rural relative poverty.

4.5.5 Heterogeneity analysis. China's digital transformation exhibits pronounced spatial differentiation, necessitating an examination of regional heterogeneity in digital poverty reduction effects. We divided China's 31 provinces into eastern, central, and western regions to analyze regional disparities.

Regression results in Table 11 reveal that digitization level significantly reduces rural relative poverty only in the western region. This indicates digital development exerts a statistically significant mitigating effect on rural relative poverty in western China, whereas impacts in east-central regions remain not obvious. This regional discrepancy may stem from latecomer advantages in western regions, enabling rapid adoption of digital technologies to expand employment and enhance productivity, thereby more effectively reducing relative poverty. In contrast, eastern and central regions with earlier digitalization and more complex economic structures exhibit diminishing marginal returns from digital enhancements, resulting in less pronounced poverty alleviation effects compared to western China.

5. Conclusions and recommendations

5.1 Conclusions

Starting from a multidimensional perspective, this paper, based on the A-F double critical value method and in line with the background of current digital development, incorporates the digitization – level dimension into the rural multidimensional relative poverty index system for measurement. It then obtains and decomposes the measured rural relative poverty index, analyzes the differences in the rural multidimensional relative poverty index across different scenarios and its dynamic trend over time. Finally, the relationship between the digitization level and rural relative poverty is further analyzed by constructing a fixed – effect model. Through the analysis, the following conclusions are drawn.

Table 11. Heterogeneity analysis results

Variables	I (1) Eastern	(2) Central	(3) Western
lnDL	−0.102	0.02	−0.108***
	(0.0819)	(0.0567)	(0.0311)
lnUL	0.069	0.0607	−0.213***
	(0.173)	(0.206)	(0.0814)
LnEDL	0.00222	−0.0268	0.0555
	(0.042)	(0.0648)	(0.0459)
lnTL	0.0314	−0.0366	−0.0276
	(0.176)	(0.101)	(0.0993)
lnHCL	−0.0602	0.0534	0.019
	(0.0596)	(0.0733)	(0.0484)
Constant	0.392	0.536	−0.561
	(0.584)	(0.835)	(0.444)
Household	YES	YES	YES
Year	YES	YES	YES
Observations	3,288	4,050	5,172
R-squared	0.0995	0.1428	0.1950

Note(s): ① Values in brackets under the regression coefficients are standard errors; ② *, **, *** represent 10%, 5%, and 1% significance levels, respectively
Source(s): Authors' own work

First, in recent years, the relative poverty situation in rural China has improved markedly. With the rapid development of China's economy and the remarkable success of the Government's poverty-alleviation efforts, coupled with the rapid development of digitalization in China, China's rural relative poverty index has shown a downward trend year by year, and the situation of relative poverty in rural areas in China has been markedly alleviated and improved.

Secondly, the relatively slow improvement in the health dimension of poverty is an important factor affecting the rural resident relative poverty alleviation process. The degree of improvement in the physical health of rural Chinese residents is much lower than that in several other dimensions. The slow improvement in the health – poverty dimension among rural residents has become a major factor contributing to their impoverishment. Future poverty – alleviation efforts should center on health issues and give them adequate attention.

Thirdly, the improvement of the digitization level plays an important role in alleviating rural relative poverty. With the development of digitization, the contribution of the digitization dimension to rural relative poverty has shown a downward trend, as has the rural relative poverty index in China. Rural digitization improvement has a positive impact on alleviating rural relative poverty through various means, significantly contributing to rural relative poverty alleviation.

Fourth, regional heterogeneity exists in the poverty-alleviation effects of digital development on rural relative poverty. Digital development has significantly reduced rural relative poverty in western China, whereas their impact remains statistically insignificant in eastern and central regions. This disparity arises from the latecomer-advantage in western regions during digital transformation, which enables faster adoption of digital technologies to broaden employment opportunities and optimize agricultural productivity, thereby reducing relative poverty more effectively.

5.2 Policy recommendations

First, in the context of digital development, the rural multidimensional relative poverty measurement system should be continuously adjusted and optimized. As China wins the battle against poverty and enters a new stage of development, the nature of poverty has shifted from absolute to relative poverty. Measuring people's pursuit of a happy life solely based on income level is insufficient and fails to reflect the problem of unbalanced and insufficient development during the development process (Fang and Zhou, 2021). Therefore, to better manage rural relative poverty in China, a relative poverty measurement index system should be established from a multidimensional perspective, considering the current digital – development process. This system can better meet the new needs of social development and people's aspiration for a better life, promoting rural development and improving rural residents' living standards.

Secondly, more attention should be paid to rural residents' relative poverty in the health level dimension, and digital development should be utilized to improve their health level. In the process of rural development, the health of rural residents has become an important factor affecting rural relative poverty alleviation (Fang and Zhou, 2021). When alleviating rural relative poverty, comprehensive measures should be taken to improve rural residents' health from aspects such as medical protection, public – health services, and health literacy. Additionally, it is necessary to utilize digital technology to better promote the alleviation of relative poverty in the health level dimension. This can be achieved by setting up online medical services such as telemedicine platforms and expert online remote consultations (Moncho – Santonja *et al.*, 2022), optimizing the distribution of rural medical resources through big data analysis of rural medical needs, establishing online health popularization platforms to enhance rural residents' self – care awareness and disease prevention knowledge, and improving rural residents' understanding of medical insurance policies and their rights and interests through the promotion of e-medical-insurance vouchers. Through these means, the health of rural residents can be comprehensively upgraded.

Thirdly, the comprehensive promotion of rural digitalization and integrated development should be based on multiple dimensions, including the economy, education, health, living environment and psychological satisfaction level, while paying attention to the aggravating effects that the digital divide may bring. Digital development is an important means to alleviate relative poverty in rural areas. It can bring new economic growth points to rural areas, improve rural residents' quality of life, and promote social equity and sustainable development. It is necessary to strengthen rural digital construction and effectively use digital means to promote rural relative poverty alleviation. In terms of rural residents' daily life (clothing, food, housing, and transportation), continuous efforts should be made to promote the construction of digital infrastructure (Bi, 2024), strengthen rural residents' digital skills training, provide more convenient public services through digital means, enrich the digital supply of rural cultural services, and enhance the digital effectiveness of rural governance, thereby improving rural residents' living standards and well-being in various aspects. In terms of agricultural production, enhance relevant policy support, strengthen the cultivation of agricultural and digital composite talents (Tang and Chen, 2022), promote the development of agricultural digital resources, promote the integration of digitalization with all aspects of agricultural production, improve the quality and efficiency of agricultural production, achieve the sustainable development of the rural economy, and promote the overall enhancement of the living standards of rural residents.

Fourth, while digitalization serves as an effective mechanism for alleviating relative poverty, its impact exhibits significant regional heterogeneity due to disparities in economic foundations, developmental stages, and sociostructural conditions. Policy interventions must adopt region-specific strategies to ensure precision in poverty alleviation efforts (Lai *et al.*, 2024). For western regions, priority should be given to enhancing digital infrastructure through increased fiscal investment to reduce network costs, leveraging internet platforms to promote specialized tourism and agricultural product marketing, and integrating digital skills training programs to enhance residents' digital literacy and participation. In central regions, emphasis should be placed on optimizing the utilization of digital infrastructure and agricultural big data, and promote the digital transformation of traditional industries. Eastern regions, meanwhile, should deepen smart manufacturing integration and advance digital convergence with service sectors and financial systems (Zhan *et al.*, 2024), thereby generating employment opportunities and stimulating income growth through industrial structure optimization. Tailored policies that align with localized conditions are imperative to harness digitalization for fostering balanced regional development and uplifting rural incomes.

5.3 Limitations and future work

In the context of digitization, this study employs the A-F double critical value method to measure rural relative poverty, uncovering its dynamic evolution and the poverty alleviation effects of digitization. The analysis utilizes six waves of rural tracking data from the CFPS database (2010–2020) to ensure indicator continuity; however, limitations persist in examining long-term dynamic trends and digitization's impacts due to constraints in the data coverage period. Future research could integrate big data analytics, geographic information systems, and other technical tools to construct a multi-source data fusion framework, thereby enabling a deeper exploration of the mechanisms through which digitization alleviates rural relative poverty.

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