# Chapter 9
# The Impacts of Unbalanced Development on Rural Multidimensional Poverty

In this chapter, we will try to expand the poverty research topic from one dimension to multiple dimensions, from absolute poverty to relative poverty, with unbalanced development as the key word. The research starts from the following two questions: Will the intertemporal changes in multidimensional poverty be consistent with the conventional poverty decomposition, and be affected by the changes in the mean and distribution structure of all indicators? If so, what are the poverty reduction effects of changes in the mean and distribution of indicators? After receiving a positive answer to the first question, our research objective is to explore the impact of "unbalanced development" on poverty in detail, and measure the contribution of the mean and distribution changes of multidimensional poverty indicators to the intertemporal changes of multidimensional poverty. That is to say, given the multidimensional nature of poverty, we will study the degree, direction and channel of the impact of unbalanced development of each indicator on individual poverty.

## 1 Literature Review

### *1.1 Poverty-Growth-Inequality Triangle in Uni-dimensional Poverty*

It has been a hot topic in the field of development economics to explore the impact of balanced or unbalanced development on poverty, which is of academic and policy significance. As for the relationship among economic growth, inequality and poverty changes, Bourguignon (Bourguignon 2003) proposed a classical analytical framework, which decomposed poverty changes into "mean effect" and "structural effect" to understand the contribution or impact of income growth and income gap changes on poverty changes in the intertemporal changes of income. International empirical evidence shows that income growth and inequality decline contribute to poverty



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alleviation (Ravallion 2001; Dollar and Kraay 2002). The results of China's rural poverty decomposition also show that the overall income growth of rural residents contributes to poverty alleviation. But rising income inequality exacerbates poverty, offsetting part of the poverty reduction effect from growth (Wan and Zhang 2006).

Through reviewing relevant literature, it is found that studies on the relationship between growth, inequality and poverty are focused on one-dimensional domains (such as income/consumption poverty). However, for countries at a higher stage of socio-economic development, the ability of one-dimensional indicators to substitute information on poverty decreases, and the academic value and policy demands of multidimensional poverty measurement increase accordingly (Sen 1982; Atkinson 2003; Ravallion 2011). China has become one of the middle and high-income countries, and poverty research from multiple perspectives is of great significance to the times. However, from the existing analysis methods and research perspectives, there is still a lack of poverty-growth-inequality triangle in multidimensional poverty.

## *1.2 Multidimensional Inequalities and Their Interaction*

Multidimensional inequality measurement is a branch of inequality research. According to the construction ideas of different indexes, they are mainly divided into Massoumi index (Maasoumi 1986), Tsui index (Tsui 1995), multidimensional Gini coefficient (Weymark 1981) and derivatives of the three kinds of indices (Duclos et al. 2011; Naga et al. 2016). Among them, Maasoumi index is a multidimensional inequality measure index constructed by two-part aggregation; Tsui index is an inequality analysis based on dominance analysis and a combination of social welfare functions (Atkinson 1970; Kolm 1911; Foster and Shorrocks 1988), namely, Atkinson-Kolm-Sen (AKS) index; the multidimensional Gini coefficient is an extension of the generalized Gini social evaluation function of a single dimension. Duclos et al. (2011) construct a local multidimensional inequality ranking based on Sen's (1976) local ranking idea to measure the impact of changes in a single dimension on changes in overall inequality.

For domestic applied research, please refer to Jiang (2015), Wang and Gao (2018). Based on the Tsui index, the former calculates the relationship between education, health and income inequality in China; The latter uses single-dimension weighted method, Tsui index and multidimensional Gini coefficient to measure multidimensional inequality, including education, income and health, and uses Tsui to decompose the contribution of each dimension to multidimensional inequality. However, the above decomposition method is only applicable to cross-sectional space, and cannot include inter-temporal changes into the analysis framework; moreover, the interactive influence channels of inequality between different dimensions are extremely complex, and multidimensional inequality indices cannot respond to such problems (Atkinson 2003). The second limitation is also a challenging problem that has so far been difficult to overcome in the field of multidimensional inequality.

### 1.3 Multidimensional Poverty Index

In the 1970s and 1980s, Amartya Sen introduced the concept of functional activities into the poverty analysis framework (Sen 1982, 1983, 1985) and proposed the theory of capability approach for human development. The main point of view is that the basic capability is composed of a series of functions, including protection from hunger and disease, satisfying nutritional needs, receiving education, participating in community activities, and so on. The loss of such functions is the cause and externalization of poverty, which lays the theoretical foundation of multidimensional poverty. In 2003, two classic papers brought multidimensional poverty research into the public eye. One was from Bourguignon and Chakravarty (2003), which extended the classical FGT index into a multidimensional space and explored the relationships between dimensions; the other was from Atkinson (2003), which linked counting deprivation method in European practice with multidimensional poverty justice, proving that multidimensional counting method can be used as an effective measure of welfare economy. The two articles set off an upsurge and a new direction for the exploration of multidimensional poverty index in the academic world. Domestic researches on multidimensional poverty include: measure the intertemporal trend of multidimensional poverty in China (Zhang 2017; Shen et al. 2018); analyze and compare regional and demographic differences in multidimensional poverty (Wang and Alkire 2009; Guo and Zhou 2016; Alkire and Shen 2017); explore the overlapping and misaligned relationship between multidimensional poverty and income poverty (Wang et al. 2016; Zhang et al. 2016; Hou and Zhou 2017); analyze the impact of dimension selection and weight setting on multidimensional poverty results from the construction of multidimensional poverty index (Guo and Wu 2012); explore the multidimensional poverty reduction mechanism for public service policies (Zhang 2017; Zhang et al. 2017).

Multidimensional poverty measurement has been recognized by the academic world, but there are disputes on how to construct multidimensional poverty index, including: (1) It is difficult to select the most appropriate variable. For example, Ravallion (2011), taking the human development index as an example, proposed that equal weight would weaken the marginal utility of improvement in some dimensions (such as education) of backward countries, which is not conducive to global comparison. (2) It is difficult to set weights. Deutsch and Silber (2005) proposed that indicators with less deprivation should be given a higher weight, but this approach proved to be unstable (Brandolini 2007); principal component analysis and factor analysis are also data-oriented representations. However, the main problem of this kind of weight analysis method is that the correlation of multiple factors is not enough to replace the impact of factors on the welfare of residents; the expert consultation method and the equal weight setting method may be influenced by the systematic deviation of experts.

To sum up, domestic and international studies on income growth, inequality and income poverty provide us with analytical approaches; if based on the perspective of multidimensional poverty, the three are still within an independent analytical framework. Different from the previous literature, we try to expand the Shapley decomposition method, and analyze contribution of unbalanced development of welfare indicators to multidimensional poverty under the multidimensional poverty framework, which is also our academic contribution to this field.

## 2 The Multidimensional Poverty Index and Decomposition Method

### 2.1 *Index System for Multidimensional Poverty Measurement*

We use AF methodology proposed by Alkire and Foster (2011) due to its intuitive and policy-relevant properties (Alkire et al. 2015). The construction of AF index as follows.

Let n represent the number of people, and let d $\geq$ 2 represent the number of dimensions which measured welfare of individual i. Thus, $x_{ij}$ represent the value on indicator j of each individual i. We identify poverty by two thresholds which indicated by z and k. The cut off indicator z identified that individual who was deprived in specified indicator j. Individual i was deprived in indicator j if $x_{ij} < z_j$, in this case, $g_{ij} = 1$. Otherwise, $g_{ij} = 0$. The AF method is based on a counting approach. We add the weighted deprivation score in all indicators of each individual and identify multidimensional poverty if one's weighted deprivation score higher than k.

Let $w_j (0 < w_j < 1)$ represent the weighting vector and $\sum_{j=1}^{d} w_j = 1$. After added deprivation score of each d indicator for individual i, we calculate individual i's overall deprivation score $c_i$, $c_i = \sum_{j=1}^{d} w_j g_{ij}$ ($c_i \in [0, 1]$). Then, we get deprivation score vector of poverty $c(k)$. Thus, $c_i(k) = c_i$ if $c_i \geq k$; and $c_i(k) = 0$ if $c_i < k$. Hence, Eq. 1 formulate the multidimensional poverty index.

$$M_0 = \frac{1}{n} \sum_{j=1}^{d} c_i(k) \tag{1}$$

where $M_0$ denotes the percentage of deprivation score of poor in whole population, where we assume that all people are deprived in all indicator.

The $M_0$ can be decomposition by headcount ratio (H) times depth which implies average deprivation level of multidimensional poverty (A). Hence, Eq. 1 can be expressed by Eq. 2.

$$M_0 = \frac{q}{n} \times \frac{1}{q} \sum_{j=1}^{d} c_i(k) = H \times A \tag{2}$$

where q refers to number of poor, H refer to headcount ratio of multidimensional poverty, and A refer to average deprived score of multidimensional poor. We can see transparently that either changes in $H$ or $A$ could change $M_0$.

Further, indicators may be analyzed in two ways: (1) calculating the deprivation level of all residents without considering the threshold $k$; (2) considering only the deprivation level of the multidimensional poor population in the case of threshold $k$:

$$\text{Incidence of deprivation without threshold: } h_j = \frac{\sum_i g_{ij}}{n} \times 100\% \tag{3}$$

$$\text{Incidence of deprivation with threshold: } h_j^{Censored} = \frac{\sum_i (g_{ij} \cdot I(c_i \geq k))}{n} \times 100\% \tag{4}$$

where, $I(\bullet)$ is a threshold function, the value is 1 when the condition in the bracket is true, otherwise it is 0. The incidence of deprivation with a threshold is generally lower than that without a threshold.

## 2.2 Shapley Value Decomposition for Multidimensional Poverty

Given that the existing Poverty-Growth-Inequality Triangle decomposition tools are only suitable for single-dimensional continuous variables (such as income), there is no multidimensional poverty analysis. This paper attempts to build a new multidimensional poverty decomposition model based on the multidimensional poverty-growth-inequality framework by applying the Shapley value decomposition (Shorrocks 2013). Based on the above ideas, this paper applies the poverty triangle analysis to the multidimensional poverty framework. According to the dual mechanism of Shapley value decomposition and AF method, it can be inferred that the inter-temporal changes of multidimensional poverty depend on the inter-temporal changes of the mean value and the gap of each index in multidimensional poverty system, as well as the relationship between the mean value and the gap of each index. Based on the foregoing logic, the detailed analysis strategies are as follows.

First, according to the Shapley decomposition of one-dimensional poverty, the change of a single indicator is decomposed into the following forms.

$$\begin{aligned} f_1(X^1) - f_0(X^0) = \frac{1}{2}\left[\left(f_1X^1 - f_0X^1\right) + \left(f_1X^1 - f_0X^1\right)\right] \\ + \frac{1}{2}\left[\left(f_1(X^1) - f_1(X^0)\right) + \left(f_0(X^1) - f_0(X^0)\right)\right] \end{aligned} \tag{5}$$

where, $f_0(X^0)$ represents the output value of a statistical indicator under the distribution of period 0 and the average level of period 0; $f_1(X^1)$ represents the output value of a statistical indicator under the distribution of period 1 and the average level of period 1; $f_0(X^1)$ represents the counterfactual result under the distribution of period 0 corresponding to the average level of period 1; $f_1(X^0)$ represents the counterfactual result under the distribution of period 1 corresponding to the average level of period 0. Obtaining the latter two counterfactual results is the key to achieving the Shapley decomposition. In the above equation, $f_1\left(X^1\right) - f_0(X^1)$ and $f_1(X^0) - f_0(X^0)$ on the right denote the difference in the statistical indicators with the same average level and different structures, so the first part is defined as the structural change; similarly, the second part contains only the difference in the average level and is defined as the "mean change".

For continuous variables, $f_0(X^1)$ can be obtained by changing all individuals in equal proportion $\overline{X}^1/\overline{X}^0$ on the basis of $f_0(X^0)$; $f_1(X^0)$ can be obtained by changing all individuals in equal proportion $\overline{X}^0/\overline{X}^1$ on the basis of $f_1(X^1)$. Here, the variation of the mean level of discrete variables is different from the conventional approach of Shapley decomposition and needs to be extended. We obtain various counterfactual distributions by repeated experiments based on the Monte Carlo random process, and counterfactual results $f_0(X^1)$ and $f_1(X^0)$, and then the corresponding decomposition results.

The multidimensional poverty index is a comprehensive result of the deprivation of multiple indicators. The average change and structural change of a single indicator can only play a limited role, and the rest will be influenced by other indicators. To estimate the impact of the average and structural changes of individual indicators on the overall multidimensional poverty, the Shapley decomposition approach is continued. he decomposition result here consists of three parts: Multidimensional poverty (the following formula is expressed as MPI) overall change = structural change of index i + average change of index i + changes caused by other indexes. It is difficult to identify simple structural changes, which need to be obtained through two decompositions:

Decomposition 1 (MPI part caused by average change of index i and remaining part):

$$MPI_1 - MPI_0 = \frac{1}{2}[(MPI_1 - MPI_{\text{Index i is the average level of Phase 0, data and structure of Phase 1}}) + \left(MPI_{\text{Index i is the data and structure of Phase 0 and average level of Phase 1}} - MPI_0\right)] + r_1 \tag{6}$$

Decomposition 2 (MPI part caused by average change and structural change of index i and remaining part):

$$MPI_1 - MPI_0 = \frac{1}{2}[(MPI_1 - MPI_{\text{Index i is the average level and structure of Phase 0 and data of Phase 1}}) + (MPI_{\text{data of Phase 0, Index i is the average level and structure of Phase 1}} - MPI_0)] + r_2 \quad (7)$$

Specifically, MPI $_{\text{Index i is the average level of Phase 0, data and structure of Phase 1}}$: a counterfactual simulation is performed on the data of Phase 1, iwhich the average level of index i is adjusted to the level of Phase 0; MPI $_{\text{Index i is the data and structure of Phase 0 and average level of Phase 1}}$: it means that the data of Phase 0 is adjusted so that the average level of dimension i is at the level of Phase 1. Similarly, MPI $_{\text{Index i is the average level and structure of Phase 0 and data of Phase 1}}$ and MPI $_{\text{data of Phase 0, Index i is the average level and structure of Phase 1}}$ respectively represent the results obtained by adjusting the average level and structure simultaneously.

Based on the above formula,

$$Con_1 = \frac{1}{2}\left[\left(MPI_1 - MPI_{\text{Index i is the average level of Phase 0, data and structure of Phase 1}}\right) + \left(MPI_{\text{Index i is the average level of Phase 1, data and structure of Phase 0}} - MPI_0\right)\right] \quad (8)$$

represents the contribution of the change in the average level of index i.

$$Con_2 = \frac{1}{2}\left[\left(MPI_1 - MPI_{\text{Index i is the average level and structure of Phase 0 and data of Phase 1}}\right) + \left(MPI_{\text{Index i is the average level and structure of Phase 1 and data of Phase 0}} - MPI_0\right)\right] \quad (9)$$

represents the joint contribution of the average change and the structural change of index i, and thus $Con_2 - Con_1$ represents the contribution of the structural change of index i. The above formula can be converted to:

$$\begin{aligned} MPI_1 - MPI_0 = {} & \frac{1}{2}[(MPI_1 - MPI_{\text{Index i is the average level of Phase 0, data and structure of Phase 1}}) \\ & + \left(MPI_{\text{Index i is the average level of Phase 1, data and structure of Phase 0}} - MPI_0\right)] \\ & + \left\{\frac{1}{2}\left[\left(MPI_1 - MPI_{\text{Index i is the average level and structure of Phase 0 and data of Phase 1}}\right)\right.\right. \\ & + \left(MPI_{\text{Index i is the average level and structure of Phase 1 and data of Phase 0}} - MPI_0\right)] \\ & - \frac{1}{2}\left[\left(MPI_1 - MPI_{\text{Index i is the average level of Phase 0, data and structure of Phase 1}}\right)\right. \\ & \left.\left. + \left(MPI_{\text{Index i is the data and structure of Phase 0 and average level of Phase 1}} - MPI_0\right)\right]\right\} \end{aligned}$$

$$\frac{1}{2}\Big[\big(MPI_1 - MPI_{\text{data of Phase 0, Index i is the average level and structure of Phase 1}}\big) + \big(MPI_{\text{Index i is the average level and structure of Phase 0 and data of Phase 1}} - MPI_0\big)\Big] = Con_1 + (Con_2 - Con_1) + rest \quad (10)$$

Specifically, $rest$ is defined as margin, mainly derived from other factors or cross relations between factors. Since index $M_0$ is obtained by combining multiple indexes, the contribution of the distribution change of a single index to $M_0$ depends on the distribution characteristics of other indexes. When other indexes are distributed differently, the contribution of a particular index may change. In addition, the discrete variables are treated as continuous[1] to ensure the logical consistency of the calculation process.

## *2.3 Data and Indexes*

The data in this chapter are from the Chinese Household Income Project Survey (CHIP) samples from rural areas in 1995, 2002 and 2013. In 1995, the survey covered 17 provinces nationwide with 7970 households and 34,618 people; in 2002, the survey covered 20 provinces with 9195 households and 37,950 people; in 2013, the survey covered 14 provinces with 9966 households and 37,063 people. There are two reasons for selecting CHIP data: First, CHIP data has a long time span and is the most appropriate database to analyze the intertemporal changes of rural poverty in China. Second, the database has detailed indexes that fit the changes of rural residents' welfare (non-income), and the statistical results are representative in rural areas.

Drawing on the design of the global multidimensional poverty index system (UNDP 2020), this paper selects nine indexes, including education, health, living conditions and employment, from CHIP data over the years to construct a multidimensional poverty system in China's rural areas (Table 1). In terms of weighting, it is difficult to demonstrate which indexes are more important than other deprivation indexes, so this paper refers to the general practice of domestic literature and assigns weights to indexes in the way of equal weight.

[1] The models in this paper involve many indexes with values of 0–1, where 1 means deprived and 0 means not deprived. The changes between 0 and 1 are manifested in three aspects: First, the change of status of a particular individual, such as the change from the state of never being deprived to the state of being deprived, reflects the change of an individual's multidimensional poverty; second, the change in the proportion of deprivation of a group, that is, the change in the proportion of 1, reflects the change in the multidimensional poverty of a group; third, the change of some people in a group from 1 to 0 and others from 0 to 1, reflects the change of the deprived individuals in a group, which contains the dynamic process of getting rid of poverty and returning to poverty.

**Table 1** Dimensions, indexes, deprivation threshold and weights of multidimensional rural poverty

| Dimensions | Indexes | Deprivation value (if the conditions are met, all household members are considered to be deprived in the index) | Data type | Weight |
|---|---|---|---|---|
| Education | *Years of schooling* | All non-school adults in the household have less years of schooling than primary school | Discrete | 1 / 9 |
| | *School attendance* | At least one school-age child in the household is out of school | Discrete | 1 / 9 |
| Health | *Health* | There is at least one member of the household who is in poor physical health | Discrete | 1/9 |
| | *Medical expenses burden* | Out-of-pocket medical expenses account for more than 50% of the total medical expenses | Continuous | 1/9 |
| Living conditions | *Safe drinking water* | No access to safe drinking water | Discrete | 1/9 |
| | *Housing* | The per capita housing area is no more than $9m^2$ | Continuous | 1/9 |
| | *Assets* | The number of small assets (TV, bicycle, motorcycle, refrigerator, washing machine) in the household is less than or equal to one; The ownership of a car or tractor, regardless of other assets, is deemed not to have been deprived | Discrete | 1/9 |
| Employment | *Unemployment* | At least one non-school adult aged 16–60 in the household is unemployed or underemployed | Discrete | 1/9 |

(continued)

**Table 1** (continued)

| Dimensions | Indexes | Deprivation value (if the conditions are met, all household members are considered to be deprived in the index) | Data type | Weight |
|---|---|---|---|---|
| | *Working environment* | At least one member of the workforce in the household is working in a bad environment (high temperature, dangerous environment), or has no pension, unemployment insurance, or has a history of unpaid wages | Discrete | 1/9 |

*Data source* Compiled by the author based on the questionnaire and statistical results of the corresponding years of CHIP

## 3 Empirical Results

### *3.1 Intertemporal Changes of Multidimensional Poverty in Rural China*

Table 2 reports the calculation results of multidimensional poverty in rural China since 1995. Taking the incidence of multidimensional poverty as an example, a vertical comparison shows that about one quarter (24.2%) of rural households were in multidimensional poverty in 1995. In the following years, the incidence of multidimensional poverty in rural areas dropped rapidly, from 11.1% in 2002 to 4.0% in 2013. Compared with the previous year, multidimensional poverty has been halved in each period.

Table 3 shows the inter-temporal changes in the mean value and gap of each multidimensional poverty index in each periods, 1995–2002 and 2002–2013. Specifically, deprivation ratio is the percentage of residents who suffer deprivation in a given index among all rural residents; threshold deprivation ratio is the percentage of multidimensional poor residents who suffer deprivation in a given index among all residents. First, the data changes shown in Table 3 are related to China's institutional arrangements and development in different periods. Taking the change of rural residents' medical expenditure burden from 1995 to 2002 as an example, 1995 coincided with the collapse of the rural cooperative system and the absence of a medical security system. During this period, most rural residents were overburdened with medical care due to unreimbursed medical expenses. (Table 3 shows that in 1995, nearly 80% of rural residents paid more than 10% of their own medical expenses; more than 90% of rural residents in multidimensional poverty suffered deprivation in this index). With the introduction and improvement of the new rural cooperative medical

**Table 2** The multidimensional poverty in rural China: 1995–2013

| | Poverty level | | | | | | Intertemporal change of poverty | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1995 | | 2002 | | 2013 | | 1995–2002 | | 2002–2013 | |
| | MPI | CI | MPI | CI | MPI | CI | Diff | Change rate (%) | Diff | Change rate (%) |
| $M_0$ | 0.091 | [0.089, 0.093] | 0.04 | [0.039, 0.041] | 0.014 | [0.039, 0.041] | −0.1 | −11.10 | 0 | −9.10 |
| *H* (%) | 24.2 | [23.7, 24.6] | 11.1 | [10.8, 11.3] | 4 | [3.8, 4.2] | −13.2 | −10.60 | −7.1 | −8.80 |
| *A* (%) | 37.6 | [37.4, 37.7] | 36.2 | [36.0, 36.4] | 35.1 | [34.8, 35.3] | −1.4 | −0.50 | −1.1 | −0.30 |

*Data source* Authors calculation based on the data from CHIP 1995, 2002 and 2013. The data source below are same and will not be repeated
*Note* MPI refers to multidimensional poverty in rural China

**Table 3** The growth and inequality for each indicator: 1995–2013

| | Deprivation ratio (%) | | | Threshold deprivation ratio (%) | | | Proportion of multidimensional poor (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1995 | 2002 | 2013 | 1995 | 2002 | 2013 | 1995 | 2002 | 2013 |
| *Years of schooling* | 4.8 | 1.2 | 1.2 | 3 | 0.5 | 0.5 | 12.4 | 4.5 | 12.5 |
| *School attendance* | 7.8 | 5 | 2.1 | 4.7 | 2.3 | 0.5 | 19.4 | 20.7 | 12.5 |
| *Health* | 24.7 | 17.8 | **20.3*** | 14.5 | 5.9 | 3.4 | 59.9 | 53.2 | 85 |
| *Medical expenditure burden* | 76.6 | 50.3 | 39.6 | 21.9 | 9.1 | 3.3 | 90.5 | 82 | 82.5 |
| *Safe drinking water* | 19.9 | 14.2 | 7.5 | 11.8 | 5.1 | 1.6 | 48.8 | 45.9 | 40 |
| *Housing* | 6.5 | 3.1 | 0.7 | 4.6 | 1.5 | 0.1 | 19 | 13.5 | 2.5 |
| *Assets* | 28.9 | 14.5 | 8.3 | 16 | 5.3 | 2.1 | 66.1 | 47.7 | 52.5 |
| *Unemployment* | 4.5 | **6.1*** | 3.6 | 2.3 | 2 | 0.7 | 9.5 | 18 | 17.5 |
| *Working environment* | 6.3 | **14*** | 2.2 | 3.1 | **4.2*** | 0.4 | 12.8 | 37.8 | 10 |

*Note* The symbol * refers to the increase of deprivation in each indicator

system, the above problems have been alleviated. In 2002 and 2013, the medical burden deprivation ratio in rural residents decreased to 50% and 40% respectively.

## 3.2 *Overlapping and Misaligned Relationship Analysis*

Based on income poverty, it was estimated in 1995 that nearly 70% (16.5/24.2% = 68.2%) of multidimensional poverty groups were also in income poverty, showing a high degree of overlap between income and non-income dimensions (see the Table 4 below). A question worth pondering is whether the observed continuous decline in multidimensional poverty in rural areas can be simply understood as a necessary phenomenon after income increases. If we examine the overlapping and misaligned changes of multidimensional poverty and income poverty over time, an obvious trend is that the changes of rural residents' income poverty and multidimensional poverty are not synchronous. The calculation results show that by 2013, only 15% (0.6 / 4 = 15%) of the multidimensional poverty groups remained in income poverty. In contrast, the proportion of multidimensional poverty groups in income poverty dropped from 31.0% in 1995 to 7.4% in 2013. The share of people falling into both categories of poverty fell from 27% in 1995 to 5% in 2013. While the proportion of income poverty rather than multidimensional poverty groups increased slightly, the proportion of multidimensional poverty rather than income poverty groups kept

**Table 4** Overlapping and misaligned relationship between multidimensional poverty and income poverty: 1995–2013

| Year | Income poverty | Multidimensional poverty | Income and multidimensional poverty (intersection) | Multidimensional poverty alone (None-income poverty) | Income poverty alone (none-multidimensional poverty) | Income or multidimensional poverty (union) |
|---|---|---|---|---|---|---|
| | Poverty headcount ratio (%) | | | | | |
| 1995 | 53.3 | 24.2 | 16.5 | 7.7 | 36.8 | 61.0 |
| 2002 | 30.5 | 11.1 | 5.4 | 5.6 | 25.1 | 36.1 |
| 2013 | 8.1 | 4.0 | 0.6 | 3.4 | 7.6 | 11.6 |
| | The proportion of people living in poverty by category in total poverty (i.e., with income or multidimensional poverty groups as the denominator) | | | | | |
| 1995 | 87% | 40% | 27% | 13% | 60% | 100% |
| 2002 | 84% | 31% | 15% | 16% | 69% | 100% |
| 2013 | 70% | 35% | 5% | 30% | 65% | 100% |

rising, from 13% in 1995 to 30% in 2013. The above trend shows that the defect of using only income standard to measure poverty is becoming more and more obvious. The reason is that, on the one hand, with the development of China's market economy, the prices of public goods related to the improvement of individual welfare are rising, which is in line with the market price; on the other hand, the income gap between residents is widening. For those groups whose income is higher than the poverty line but still at a low level, their limited income is not enough to improve their multidimensional welfare, and the measurement of poverty from a multidimensional perspective becomes more prominent in the new era. The consideration of multidimensional poverty can be an important supplement to the study of poverty in the new era.

## *3.3 Growth—Inequality—Deprivation Analysis*

Through the preliminary analysis of the changes of deprivation indexes, we can find that the intertemporal changes of indexes have an impact on the whole population, and then on the multidimensional poverty groups. The change of each index has different marginal contribution rate to the above different groups, leading to the uncertainty of its effect. To simplify the analysis, this part first discusses the growth-inequality-index deprivation relationship.

The first two columns Table 5 shows the mean value and structure on each index—A negative value indicates a decrease in the degree of deprivation, while a positive value indicates an increase in the degree of deprivation. Column 3–5 shows the effects of intertemporal changes. The total difference is determined by the combined mean value and structural changes. Although the deprivation ratio of most indexes was negative (improved) in the intertemporal changes, there were some indexes that were positive (worsened). According to the direction of the positive and negative forces (and their resultant forces) of each index, it can be divided into four situations. First, the mean value improves while the structure worsens, the former overtakes the latter, and the total effect is improvement. The deterioration of "structure" indicates that the uneven development of indexes has led to differentiation among different populations, while the improvement of "mean value" indicates that the average level of indexes is constantly improving. In this process, although the deterioration of "structure" offset part of the development effect, the improvement of "mean value" was greater, so the resultant of the changes of the intertemporal distribution contributed to the reduction of the deprivation degree. For example, the indexes of health and small assets for the period 1995–2002 fall into the first category. Second, the "mean value" improves while the "structure" worsens, with the former and the latter at similar levels, and the two cancel each other out. It shows that in unbalanced development, the widening gap of a certain index completely offsets the improvement of the mean value. Examples of this situation are the education level of residents in 2002–2013. Third, both the mean value and structure are improving, and the total effect is the sum of the two. It is in line with the positive development trend, with

**Table 5** Intertemporal changes of mean and inequality on each index without thresholds (%)

| | | Base period (secondary axis) | Given period (secondary axis) | Difference | Changes by inequality | Changes by growth |
|---|---|---|---|---|---|---|
| 1995–2002 | *Years of schooling* | 4.8 | 1.2 | −3.5 | −1.4 | −2.1 |
| | *School attendance* | 7.8 | 5.0 | −2.8 | 0.0 | −2.8 |
| | *Health* | 24.7 | 17.8 | −6.9 | 7.7 | −14.6 |
| | *Medical expenditure burden* | 76.6 | 50.3 | −26.4 | −25.9 | −0.5 |
| | *Safe drinking water* | 19.9 | 14.2 | −5.7 | 0.0 | −5.7 |
| | *Housing* | 6.5 | 3.1 | −3.5 | 0.3 | −3.7 |
| | *Assets* | 28.9 | 14.5 | −14.3 | 12.1 | −26.4 |
| | *Unemployment* | 4.5 | 6.1 | 1.6 | −0.2 | 1.8 |
| | *Working environment* | 6.3 | 14.0 | 7.7 | 0.0 | 7.7 |
| 2002–2013 | *Years of schooling* | 1.2 | 1.2 | 0.0 | 2.0 | −2.1 |
| | *School attendance* | 5.0 | 2.1 | −2.9 | 0.0 | −2.9 |
| | *Health* | 17.8 | 20.3 | 2.5 | −0.6 | 3.2 |
| | *Medical expenditure burden* | 50.3 | 39.6 | −10.7 | −8.4 | −2.3 |
| | *Safe drinking water* | 14.2 | 7.5 | −6.7 | 0.0 | −6.7 |
| | *Housing* | 3.1 | 0.7 | −2.4 | 0.5 | −2.9 |
| | *Assets* | 14.5 | 8.3 | −6.2 | −2.4 | −3.8 |
| | *Unemployment* | 6.1 | 3.6 | −2.5 | 0.0 | −2.5 |
| | *Working environment* | 14.0 | 2.2 | −11.8 | 0.0 | −11.8 |

indexes constantly improving and the gap narrowing, including: Improvement in education level in 1995–2002, improvement in small assets and self-pay medical burden in 2002–2013. In particular, the decline in the incidence of medical expenditure burden deprivation is mainly due to changes in the structure, which reflects the positive effect of the establishment of the new rural cooperative medical insurance system on equal access to medical services for rural residents from one side. Fourth, the total effect is almost single (mean or structural) effect. It is a special intertemporal change. Those with only improvement in mean value include children enrollment and safe drinking water, and housing for 1995–2013; those with worsening in mean value include: employment for 1995–2002; those with only improvement in structure include medical burden for 1995–2002.

## 3.4 Growth—Inequality—Multidimensional Poverty Analysis

This section will measure the marginal impact of changes in the "mean" and "structure" of a single index on the intertemporal changes in multidimensional poverty, taking into account the margin. The analysis path is as follows: The mean value and structural changes of a single index affect the degree of deprivation of a single index, and ultimately affect the change of multidimensional poverty. Table 6 reports the contribution of the "mean value" and "structural" changes of each index to multidimensional poverty. The sum of "mean change" + "structural change" + "residual change" in each row is equal to 100%. Where, a positive value indicates the improvement of a certain index on poverty, a negative value indicates worsening. The higher the absolute value, the greater the contribution. In addition, since the multidimensional poverty index is composed of nine indexes, in addition to the changes in the indexes, there is the combined effect of eight other indexes, whose impact is classified as "margin", that is, the part that cannot be directly explained for a specific index. Because of the complexity of the information contained in the margin, it is not the focus of this paper. Columns 2–4 of Table 6 show the relative contributions of each index to three multidimensional poverty indexes. Starting from the fifth column, the contributions of inter-temporal changes in the mean and structure of each index and the combined change of other indexes (margin) to the changes of $M_0$, H and A are given respectively. For example, columns 5_7 in row 4 give the relative contributions of mean, structure, and rest of educational background to $M_0$, respectively, which add up to 100%.

On the whole, the decomposition of "poverty triangle" in different periods provides a multidimensional welfare change map of rural residents in China. It can be found that the intertemporal changes of indexes and their impact on multidimensional poverty of rural residents are closely related to China's institutional reform and policy implementation, as well as the international development pattern and economic crisis. Specifically, 1995–2002 was the period of China's Seven-Year Priority Poverty Alleviation Program. China lifted rural residents out of poverty by means of work-for-the-dole scheme, strengthening infrastructure development, and improving education, culture and public health services. In this period, taking $M_0$ for example, the calculation results show that: The increase in the types of small assets held by rural residents, the reduction in the burden of self-pay medical expenditure and the improvement of the health status of rural households made the most significant contributions to the intertemporal reduction of multidimensional poverty, with the relative contributions of 31.6%, 15.2% and 14.0%, respectively. The positive contribution of safe drinking water, housing area, education level and children enrollment to multidimensional poverty is around 5–10%. However, in the historical period

**Table 6** Contribution of changes in mean and structure of indexes to changes in multidimensional poverty (%)

| | Relative contribution | | | $M_0$ (%) | | | H(%) | | | A(%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Contribution to $M_0$ | Contribution to H | Contribution to A | Mean change | Structural changes | Rest | mean change | Structural changes | Rest | mean change | Structural changes | Rest |
| 95–02 | | | | | | | | | | | | |
| *Years of schooling* | 7.9 | 7.1 | 21.7 | 4.7 | 3.1 | 92.1 | 4.4 | 2.7 | 92.9 | 12.0 | 9.6 | 78.3 |
| *School attendance* | 5.8 | 5.4 | 11.2 | 6.0 | −0.3 | 94.2 | 5.6 | −0.2 | 94.6 | 12.5 | −1.4 | 88.8 |
| *Health* | 14.0 | 14.1 | 9.5 | 28.5 | −14.5 | 86.0 | 28.9 | −14.9 | 85.9 | 17.1 | −7.6 | 90.5 |
| *Medical expenditure burden* | 15.2 | 16.0 | −6.9 | 0.7 | 14.5 | 84.8 | 0.8 | 15.3 | 84.0 | −0.7 | −6.3 | 106.9 |
| *Safe drinking water* | 9.6 | 9.6 | 7.7 | 12.7 | −3.0 | 90.4 | 12.7 | −3.1 | 90.4 | 9.8 | −2.1 | 92.3 |
| *Housing* | 8.7 | 8.1 | 21.9 | 9.5 | −0.9 | 91.3 | 8.9 | −0.9 | 91.9 | 23.4 | −1.5 | 78.1 |
| *Assets* | 31.6 | 32.4 | 15.4 | 57.3 | −25.7 | 68.4 | 58.7 | −26.4 | 67.6 | 29.7 | −14.3 | 84.6 |
| *Unemployment* | −3.9 | −3.8 | −5.2 | −3.8 | −0.1 | 103.9 | −3.7 | −0.1 | 103.8 | −5.5 | 0.3 | 105.2 |
| *Working environment* | −14.8 | −14.3 | −23.2 | −15.6 | 0.9 | 114.8 | −15.0 | 0.8 | 114.3 | −24.9 | 1.7 | 123.2 |
| 02–13 | | | | | | | | | | | | |
| *Years of schooling* | 1.0 | 1.0 | 1.4 | 7.4 | −6.4 | 99.0 | 7.5 | −6.5 | 99.0 | 10.2 | −8.8 | 98.6 |
| *School attendance* | 10.2 | 10.0 | 14.5 | 9.9 | 0.4 | 89.8 | 9.6 | 0.3 | 90.0 | 13.9 | 0.6 | 85.5 |
| *Health* | −6.3 | −6.5 | 0.1 | −7.4 | 1.1 | 106.3 | −7.6 | 1.2 | 106.5 | −0.1 | 0.2 | 99.9 |

(continued)

**Table 6** (continued)

| | Relative contribution | | | $M_0$ (%) | | | H(%) | | | A(%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Contribution to $M_0$ | Contribution to H | Contribution to A | Mean change | Structural changes | Rest | mean change | Structural changes | Rest | mean change | Structural changes | Rest |
| *Medical expenditure burden* | 10.1 | 10.4 | 1.3 | 2.4 | 7.7 | 89.9 | 2.5 | 8.0 | 89.6 | 1.2 | 0.1 | 98.7 |
| *Safe drinking water* | 18.7 | 18.5 | 18.9 | 18.3 | 0.4 | 81.3 | 18.2 | 0.3 | 81.5 | 17.1 | 1.8 | 81.1 |
| *Housing* | 9.0 | 8.2 | 32.9 | 9.8 | −0.8 | 91.0 | 9.0 | −0.8 | 91.8 | 38.2 | −5.2 | 67.1 |
| *Assets* | 17.5 | 17.1 | 24.9 | 11.4 | 6.1 | 82.5 | 11.2 | 5.9 | 82.9 | 14.4 | 10.5 | 75.1 |
| *Unemployment* | 6.7 | 6.7 | 7.2 | 6.6 | 0.2 | 93.3 | 6.5 | 0.2 | 93.3 | 7.4 | −0.2 | 92.8 |
| *Working environment* | 30.3 | 29.9 | 39.2 | 30.2 | 0.1 | 69.7 | 29.9 | 0.1 | 70.1 | 38.8 | 0.3 | 60.8 |

*Notes* (1) The numerical results in the table are the ratio between the change in M0 caused by each type of change and the total change in M0. When the sign is positive, it indicates that the direction of such a change is the same as that of M0. (2) The sum of the contributions of a single index to M0, H and A (the sum of each of the three columns on the left side of the table) is not 100, because there is still some quantitative correlation between the indexes, leading to part of the change of the final index (such as M0) from the common influence of multiple indexes from the migrant labor tide to the migrant labor shortage, we have observed that the two indexes of unemployment and working environment contribute negatively to the multidimensional poverty of rural residents. Of course, as China weathered the 2008 financial crisis smoothly and improved the employment environment for migrant workers by regulating labor laws and the minimum wage system, we will no longer see such negative contributions.

From 2002 to 2013, China vigorously carried out policies to benefit the poor and rural residents. During this period, the Chinese government abolished the agricultural tax, explored the rural land transfer system, promulgated the *Outline for Development-oriented Poverty Reduction for China's Rural Areas* (2001–2010), and strengthened infrastructure construction in poor rural areas. Taking $M_0$ as an example, the top three contributors to poverty reduction are working environment, safe drinking water and small assets, which contribute 30.3%, 18.7% and 17.5% to $M_0$, respectively. The contribution of the improvement of "mean value" of rural residents' working environment to the decrease of M0 was 9.2%, and the change of "structure" had almost no effect. The improvement of safe drinking water is also mainly due to the "mean" effect, which echoes the positive results of the safe drinking water project of the Chinese government.

# 4 Conclusion

This paper expands the perspective of poverty research from one-dimensional income poverty to multidimensional poverty. Referring to the "poverty triangle" analysis method of studying the impact of income growth and income gap on income poverty, this paper creatively applies the Shapley value decomposition method to establish a multidimensional poverty decomposition model, and evaluate the multidimensional poverty reduction results in rural China from 1995 to 2013. The main findings of this paper include: First, from 1995 to 2013, China's rural multidimensional poverty rate dropped rapidly, demonstrating the great achievements of China's poverty alleviation. Second, this paper finds that in the process of decreasing multidimensional poverty in rural areas, changes in the mean value and structure of each index will have an impact on poverty. Generally speaking, an increase in the mean value has a positive impact on poverty reduction, but the unbalanced development of some indexes offsets some of the effects of poverty reduction, and slows down the decline of multidimensional poverty.

In addition to the empirical research conclusions, two conclusion are worth considering: First, the improvement of people's access to basic development rights is the main reason for the reduction of multidimensional poverty in rural China in the past 20 years, but there is a gap in access to rights among different groups, which will offset part of the poverty reduction effect once the gap becomes larger. Second, the idea of poverty alleviation should be based on deeper empowerment and capacity improvement, rather than simply on income growth. The study found that addressing income poverty at a lower level (a lower level of income improvement, or crossing the income poverty line at a lower level) does not address capacity deficiency, because low-income people still face barriers to purchasing and creating welfare products, meaning that poverty is not completely eliminated. Therefore, we propose that low-level income poverty alleviation (crossing the income poverty line at a lower level) cannot solve the problem of capacity deficiency, and the poverty alleviation approach needs to trace back to the root causes of rural poverty, and eliminate the narrow thinking of poverty alleviation through income. We should re-examine the important value of shared development in alleviating poverty, and establish the anti-poverty policy thinking on the basis of deeper "empowerment" and capacity improvement. Therefore, a more equitable and inclusive development approach, as well as attention to equal access to multidimensional welfare indicators and the accompanying multidimensional poverty, will be of reference significance to "establish a long-term mechanism for alleviating relative poverty" after 2020.

The policy implications of the study are that, first of all, poverty alleviation needs to trace back to the root causes of rural poverty, and eliminate the narrow thinking of poverty alleviation through income. We should pay attention to the important value of multidimensional poverty theory and practice, and base anti-poverty policy ideas on empowerment and capacity improvement. Second, we should be alert to the further widening of the gap in welfare indicators among residents, so as to avoid the multidimensional poverty caused by unbalanced development. The main policy recommendations are to trace back the root causes of rural poverty, to break the old thinking of poverty alleviation through income, and to re-examine the importance of shared development in alleviating poverty. Appropriate administrative intervention can be used to strengthen the quantity and quality of infrastructure and public services in backward areas, and reduce the marginal price of welfare products for the groups at the lower end of the income distribution, and pay attention to balanced development and pro-poor development while pursuing efficiency. On the whole, to prevent the return to poverty and alleviate relative poverty in the future, attention should be paid not only to the growth of welfare indicators, but also to the gap between these welfare indicators among residents. Through the combination of inclusive development and preferential policies, a long-term mechanism for alleviating multidimensional relative poverty should be established to promote people's well-being to a new level.

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