Research article

Regional inequality in China's educational development: An urban-rural comparison

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ABSTRACT

In the past two decades, regional inequality in China's educational development, especially between urban and rural areas, has continued to narrow. An in-depth discussion of this phenomenon and the mechanisms behind it will not only help China build a high-quality educational system, but also draw lessons from Chinese practices to guide the reduction of global educational inequality. The comprehensive evaluation results show that China's rural EDL surpassed urban EDL in 2013; in 2003–2019, the urban/rural EDL increased from 0.29 to 0.22 to 0.50 and 0.54, respectively, and the urban-rural EII decreased from 1.31 to 0.92. Spatially, urban/rural EDL in the eastern and northeastern regions is higher than that in the central and western regions, the urban-rural EII in the eastern and northeastern regions is lower than that in the central and western regions. The CV and Theil index show that regional disparity in national urban/rural EDL has been narrowing, and regional inequality in urban-rural EII has also been declining; the decomposition of the Theil index indicates that these decreases in inequality are mainly from the reduction of the urban/rural educational development gap within the regions. The large-scale population migration driven by rapid industrialization and urbanization, and the adjustment of urban-rural and regional relationship promoted by the transformation of national policies such as regional coordinated development strategy and *hukou* system reform, are the main reasons for the evolution of regional inequality in China's urban and rural educational development.

1. Introduction

Education is a social good to cultivate people [1]. Through developing people's intelligence, improving people's skills and shaping people's thoughts, education improves individuals' abilities to understand, utilize and transform the world, thus promoting socio-economic development and reducing inequality [2,3]. According to data for 114 countries in 1985–2005, one extra year of schooling is associated with a reduction of the Gini by 1.4 points [4]. Therefore, countries around the world attach great importance to educational development, and the United Nations (UN) include educational development as an important element in the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs). In this context, education in underdeveloped countries has grown rapidly, and the global gap in educational development continues to narrow [5]. Nevertheless, more than 200 million school-age children worldwide are still out of school, primarily in sub-Saharan Africa, Central Asia, and South Asia. Compared to

high-income countries where all urban and rural children reach lower secondary school, these two rates in low-income countries are 91% and 80%, respectively [6]. Meanwhile, the COVID-19 pandemic is reversing hard-won gains in improving global education and widening the gap between high-income and low-income countries in educational development [7]. Given the important role of education in achieving other SDGs [8,9], the worsening situation of inequality in educational development will pose a great challenge to global sustainable development.

China has long held the ideal of "education without discrimination" since ancient times, and the government has been committed to establishing a public educational system that is accessed by all. In response to the transformation of the economic system from a planned economy to a market economy, the government decentralized the previously highly centralized education administration to local governments at the beginning of the reform and opening-up [10–13], making it clear that the authority and responsibility for basic education rested with local governments. As a result, the difference in the ability to allocate educational resources between regions determines the spatial inequality of educational development [11]. Since the allocation of public education resources in China is identity-based, school-age children with agricultural *hukou* receive education in rural areas, and those with non-agricultural *hukou* receive education in urban areas. If the former wants to enter the city for public education, they will face many harsh restrictions, which brings huge inequality between urban and rural education [14–19]. To reverse this situation, the government has committed to promote educational system reform and strengthen investment in rural education since the beginning of this century. Through measures such as optimizing school layout and improving school conditions, the development level of rural education has been improved and the gap between urban and rural education has continued to narrow, providing important support for China's rapid economic development.

Currently, China's economy has shifted from a high-speed growth stage to a high-quality development stage [20]. Systematically exploring the evolution of urban and rural inequality in China's educational development and its mechanisms can help clarify the outstanding problems in China's educational development, guide educational policy formulation to build a high-quality educational system, and then consolidate the human capital support for high-quality development. At the same time, it also helps to deepen the understanding of the Chinese model that has achieved remarkable results in promoting regional educational equality, and provides the "Chinese experience" for reducing educational inequality and global sustainable development.

The rest of the article is structured as follow: based on the literature review in Section 2, Section 3 constructs a comprehensive evaluation index system to measure urban/rural educational development level (EDL) and introduces the data and methodology. Section 4 presents the empirical results derived from the analysis. Section 5 discusses countermeasures for the development of urban and rural education in China and the policy implications of this study for reducing global educational inequality. Finally, Section 6 summarizes the key points of the study.

2. Literature review

In the nearly three decades between the founding of the People's Republic of China (PRC) and the reform and opening-up, the central government assumed primary responsibility for the supply and financing of education, providing a large number of educational opportunities for the children of workers and peasants and transforming educational development from a state of extreme inequality to one of relative equality [13,21]. Since then, selecting and training talents for economic development has replaced the elimination of class differences as the main function of education [21]. Thus, the central government actively promotes educational reform, decentralized administrative and fiscal authority, and privatizes educational costs [10,11,13]. Although these measures have mobilized new resources to support educational development, they also exacerbate regional educational inequalities [11].

The Compulsory Education Law of the PRC has guaranteed the right of school-age children to receive compulsory education, but
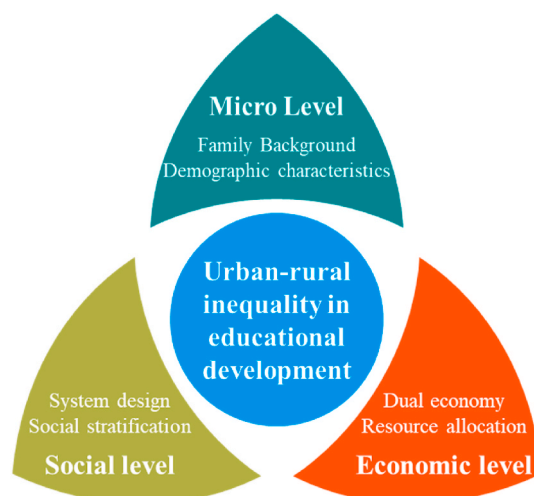

Fig. 1. Causes of urban-rural inequality in China's educational development.

due to the dominant role of market mechanism, educational resources tend to gather in geographically advantageous areas, leading to regional inequality in education, which is mainly manifested as urban-rural inequality [14,15,18,22] and coast-inland inequality [13,22,23]. Promoted by social and economic development, urban-rural inequality gradually replaces coastal-inland inequality as the main cause of China's regional educational gap [22]. In terms of the level of education, the inequality between urban and rural areas is significantly greater in non-compulsory education than in compulsory education [24]. Compared to the proportion of students from urban areas going on to key senior high schools, this figure is nearly 20 percentage points lower for rural junior high school graduates [25]. In the stage of higher education, the proportion of students from rural areas entering 211/985 universities is significantly smaller than that from urban areas [25,26]. Spatially, the gap between urban and rural educational development in the eastern region is smaller than that in the central and western regions [27]. Since 2000, the Chinese government has taken a series of measures to reduce urban-rural educational inequality, including student loans, scholarships, and policies to provide grants to poor students, but they have not been universally effective in reducing educational inequality [19,27]. In the context of population mobility, urban-rural inequality in educational development is also highlighted by the gap between migrant and local urban children [28,29].

The urban-rural inequality in China's educational development has deep social and economic roots (Fig. 1). The urban-rural divide and social stratification are the largest contributors, and the compartmentalized urban-rural *hukou* system and growing urban-rural economic inequality also deepen institutional barriers and class stratification [19]. Specifically, the *hukou* system divides people into agricultural and non-agricultural parts, and this system, which is closely tied to the distribution of welfare, allows the gap between urban and rural residents in public services such as education to develop and widen [14,30,31]. Due to the stability of the institution that links children from different social backgrounds to educational resources, the urban-rural inequality in educational development are persistent [32,33]. Meanwhile, the urban-rural dual structure based on the *hukou* system leads to a general urban-rural social stratification, which exacerbates inequalities in urban-rural educational development through the inheritance of family education, access to schooling, and the acquisition of social capital [34]. The relatively advantaged class living in urban areas has more educational opportunities and quality educational resources, while the disadvantaged rural groups are often excluded [19,35–37]. In the context of decentralized education administration, economic differences often reflect the gaps in social infrastructure support [11,38]. Urban areas featured by socialized production have a better-funded and higher-quality educational system than rural sectors, which are featured by smallholder production [11], and urban residents are more willing and able to pay for educational services [13]. In addition, the scale effect of factor agglomeration makes educational financial investment concentrated in urban areas [39]. At the micro level, demographic characteristics such as health status and occupation, as well as family background such as income and parental education, affect inequalities in urban-rural educational development by influencing individual/household decision-making [27,40,41]. As the cultural reproduction theory points out, parents' educational expectations, cultural capital, and human capital are internalized into children's motivation and learning performance, which indirectly translate into educational opportunities, causing urban-rural inequality in educational development [34].

The existing literature has provided useful information about the complex social phenomenon of China's urban-rural inequality in educational development. However, most of these studies use single indicators such as enrollment rate, years of schooling, and academic achievement, leading to a lack of comprehensive and systematic understanding of this phenomenon. On the other hand, there are many studies on the causes of inequality between urban and rural educational development, but most of them are static analysis, and there are few analyses on the dynamic changes of such inequality and its causes. In fact, the inequality between urban and rural educational development in China has been narrowing since the 21st century [42], but the mechanism behind this evolution is not well understood. Employing a dataset on China's urban-rural educational development in 2003–2019, this study constructs a

Table 1
Comprehensive evaluation index system of urban/rural EDL.

Dimension	Primary indicator	Secondary indicator	Direction	Weight
Educational opportunities	Secondary school	Teacher-student ratio	Positive	0.0452
		Class size (Person)	Negative	0.0483
		Number of library books per student (Volume)	Positive	0.0615
		Number of computers per student (Set)	Positive	0.0459
		Lab area per student (m^2)	Positive	0.0349
		PC-room area per student (m^2)	Positive	0.0391
		Value of fixed assets per student (10,000 RMB)	Positive	0.0430
		Ratio of full-time teachers with bachelor's degree or above (%)	Positive	0.0688
		Ratio of full-time teachers with middle and above professional rank (%)	Positive	0.0458
	Primary school	Teacher-student ratio	Positive	0.0520
		Class size (Person)	Negative	0.0483
		Number of library books per student (Volume)	Positive	0.0467
		Number of computers per student (Set)	Positive	0.0527
		Lab area per student (m^2)	Positive	0.0500
		PC-room area per student (m^2)	Positive	0.0507
		Value of fixed assets per student (10,000 RMB)	Positive	0.0323
		Ratio of full-time teachers with bachelor's degree or above (%)	Positive	0.0661
		Ratio of full-time teachers with middle and above professional rank (%)	Positive	0.0462
		Ratio of external teaching sites in the number of primary schools (%)	Negative	0.0570
Educational outcomes	Educational attainment	Ratio of the population with education level of junior secondary school and above in population aged 6+ (%)	Positive	0.0655

comprehensive evaluation index system of urban/rural EDL, and then reveals the evolution of inequality in China's urban and rural educational development and the mechanism behind it.

3. Materials and methods

3.1. Index system

According to Coleman [43], equality in education includes three dimensions: one is to provide educational facilities for the school-age population, the other is to ensure that citizens have access to a minimum level of education, and the third is to ensure that disadvantaged groups have equitable access to education. These three interpretations represent equality of opportunity, outcome, and rights in education, respectively. In China, it is the right and obligation of citizens to receive education. Therefore, this study focuses on the two dimensions of educational opportunities and outcomes to dissect EDL, and then explores the evolution of urban-rural inequality in educational development. Based on the availability of data and the principles of systematic and scientific approach to the selection of indicators, a comprehensive evaluation index system of urban/rural EDL consisting of 3 primary indicators and 20 secondary indicators is constructed (Table 1). The connotation of each indicator indicates that class size and the proportion of external teaching sites in the number of elementary schools are negative indicators, while the rest are positive ones.

Due to the different scale of each indicator, a min-max scaling is employed to standardize the raw data. The weight of each indicator is determined by a combination of subjective and objective weighting methods. First, the objective weight ω_j' and subjective weight ω_j'' of indicator j are obtained by CRITIC (criteria importance through intercriteria correlation) and AHP (analytic hierarchy process) methods, respectively. Please refer to Diakoulaki et al. [44] for the calculation of the former and Opitz et al. [45] for the latter. Second, the function is constructed based on the principle of minimum relative information entropy:

$$F = \sum_{j=1}^{n} \omega_j \left(\log \omega_j - \log \omega_j' \right) + \sum_{j=1}^{n} \omega_j \left(\log \omega_j - \log \omega_j'' \right) \tag{1}$$

where $\omega_j > 0$, and $\sum_{j=1}^{n} \omega_j = 1$. Furthermore, the optimal solution based on the method of Lagrange multiplier is the weight of indicator j:

$$\omega_j = \sqrt{\omega_j' \omega_j''} \Big/ \sum_{j=1}^{n} \sqrt{\omega_j' \omega_j''} \tag{2}$$

Therefore, urban/rural EDL of province i is:

$$EDL_i = \sum_{j=1}^{n} \omega_j \bar{x}_{ij} \tag{3}$$

where $\bar{x}_{ij}$ is the standardized value of indicator j in province i.

3.2. Measurement of regional educational inequality

(1) Educational inequality index

Based on the calculated urban and rural EDL, the educational inequality index (EII) is employed to measure the gap between urban and rural educational development, and its formula is:

$$EII_i = EDL_{iu} / EDL_{ir} \tag{4}$$

where EDL_{iu} and EDL_{ir} represent urban and rural EDL in province i, respectively; EII_i is the inequality index of urban and rural educational development in province i. The closer the EII_i is to 1, the more balanced the urban and rural educational development is; otherwise, the gap between urban and rural educational development is greater.

(2) Coefficient of variation

The coefficient of variation (CV), which is defined as the ratio of the standard deviation to the mean, is a standardized measure of the dispersion of the probability distribution or frequency distribution. Here, CV is employed to measure the dispersion of EDL and is calculated as follows:

$$CV = \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left(EDL_i - \overline{EDL} \right)^2} \Big/ \overline{EDL} \tag{5}$$

where n denotes the number of provinces, and $\overline{EDL}$ is the average of EDL.

(3) Theil index

The Theil index is a statistic originally used to measure income disparities [46]. Later, it was widely used to analyze differences in socioeconomic phenomena such as energy consumption and population distribution. Here, the Theil index is used to investigate the regional disparities of urban/rural educational development and is defined as:

$$Theil = \frac{1}{n} \sum_{i=1}^{n} \frac{EDL_i}{\overline{EDL}} \log\left(\frac{EDL_i}{\overline{EDL}}\right) \tag{6}$$

As an index to measure the extent of disparities, the Theil index is well differentiable and measures the contribution of disparities within regional subgroups and disparities between regional subgroups to the total disparity [47]. The sum of these two parts is the Theil index. According to the National Bureau of Statistics of China, mainland China can be divided into four regions, i.e., eastern China, central China, western China, and northeastern China. Here, we decompose the Theil index to reveal the contribution of educational development gap within and among these four regions to the national educational development gap. The decomposition will assume the following form:

$$Theil = \sum_{k=1}^{K} EDL_{g(k)}^{p} \log\left(\frac{EDL_{g(k)}^{p}}{n_k/n}\right) + \sum_{k=1}^{K} EDL_{g(k)}^{p} \left(\sum_{m \in g_k} \frac{EDL_m^p}{EDL_{g(k)}^p} \log \frac{EDL_m^p \Big/ EDL_{g(k)}^p}{1/n_k}\right) \tag{7}$$

Therefore, the disparities between and within the four regions have the following expressions:

$$Theil_{inter} = \sum_{k=1}^{K} EDL_{g(k)}^{p} \log\left(\frac{EDL_{g(k)}^{p}}{n_k/n}\right) \tag{8}$$

$$Theil_{intra} = \sum_{k=1}^{K} EDL_{g(k)}^{p} \left(\sum_{m \in g_k} \frac{EDL_m^p}{EDL_{g(k)}^p} \log \frac{EDL_m^p \Big/ EDL_{g(k)}^p}{1/n_k}\right) \tag{9}$$

where k denotes the number of regions divided by mainland China, and its value is 4; $g(k)$ refers to one of the four regions; n_k is the number of provinces in region $g(k)$, and $\sum_{k=1}^{K} n_k = 31$; EDL_m^p and $EDL_{g(k)}^p$ represent the national share of EDL in province m and the national share of the sum of EDL in all provinces of region $g(k)$, respectively.

3.3. Data source and processing

The basic geographic data used in this study were obtained from the Resource and Environment Science and Data Center (http://www.resdc.cn/). Data on educational opportunities were obtained from the Educational Statistics Yearbook of China (2003–2019), and data on educational outcomes were obtained from the China Population Statistics Yearbook (2004–2006) and the China Population & Employment Statistics Yearbook (2007–2020). According to the Ministry of Education of the PRC, primary educational institutions include primary schools and external teaching sites, and secondary educational institutions include regular senior secondary schools (combined secondary schools, regular high schools and 12-year schools) and junior secondary schools (regular junior secondary schools, 9-year schools and vocational junior secondary schools). Statistically, urban areas include metropolitan areas and cities, while rural areas refer to areas outside of cities, including market towns and villages. Since inequality in higher education is to some extent an extension of prior inequality [48,49], this study focuses on inequality in urban/rural primary and secondary education.
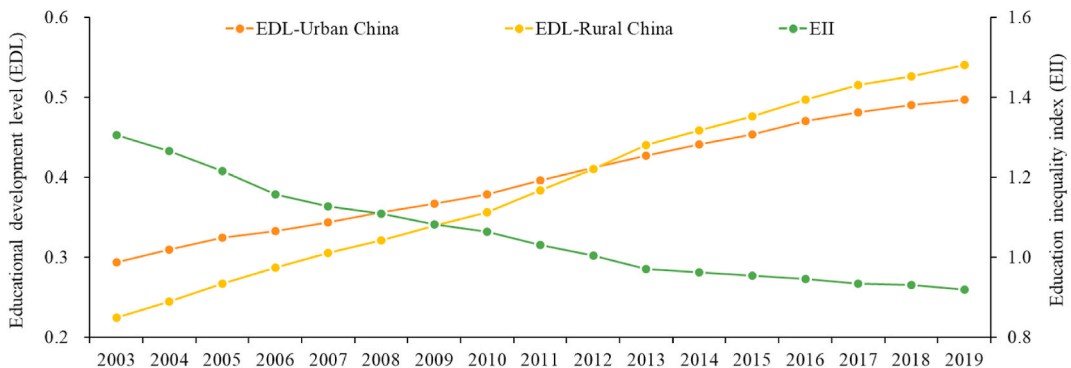

Fig. 2. The evolution of urban/rural EDL and EII in China from 2003 to 2019.

4. Results

4.1. Spatial and temporal patterns of urban and rural EDL in China

Since the reform and opening-up in 1978, the Chinese government has committed to strengthen its policy support for rural development to promote the optimization of urban-rural relationships, especially the strategy of balancing urban and rural development proposed in 2003, which marked a new development stage in China's urban-rural relationship. From 2003 to 2019, China's urban and rural EDL increased from 0.29 to 0.22 to 0.50 and 0.54, with average annual growth rates of 3.32% and 5.61%, respectively (Fig. 2). Accordingly, the urban-rural EII decreased from 1.31 to 0.92, with an average annual decline rate of 2.17%. Before 2013, urban EDL was higher than rural EDL; after that, rural EDL surpassed urban EDL, and the gap between the two has steadily widened.

Spatially, the provincial urban and rural EDL in the eastern and northeastern regions are significantly higher than those in the central and western regions, especially in developed areas such as Beijing, Tianjin, Shanghai, Zhejiang, and Jiangsu, which are leading the country in both urban and rural educational development (Fig. 3a and b). In 2003, the province with the lowest urban EDL was Tibet, followed by Guizhou and Gansu. On the other end of the spectrum were the three municipalities in the eastern region. The
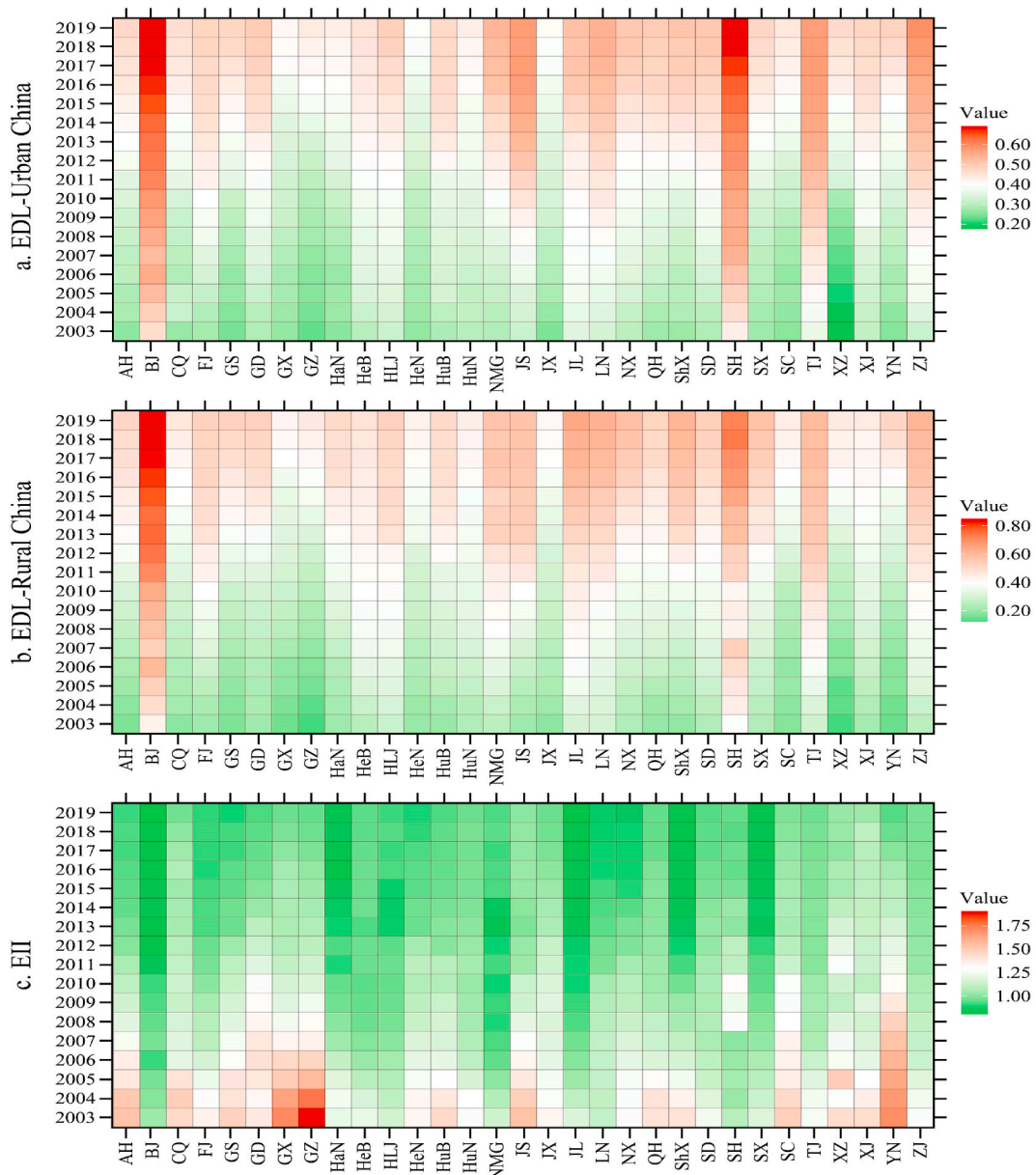

Fig. 3. The provincial patterns of urban/rural EDL and EII in China from 2003 to 2019.

province with the lowest rural EDL was Guizhou, with Tibet and Yunnan being very close to that level, and they were the only three provinces with rural EDL lower than 0.15. Beijing and Shanghai had the highest rural EDL and were the only two provincial administrative units with rural EDL exceeding 0.30, reaching 0.44 and 0.39 respectively. In 2019, the province with the lowest urban EDL was Henan, followed by six provinces with values between 0.40 and 0.45, including Jiangxi, Guangxi, Hainan, Hunan, Guizhou and Sichuan; the only two provinces with urban EDL greater than 0.60 were Shanghai and Beijing. The province with the lowest rural EDL was Jiangxi, followed by Guangxi and Henan, and there were another seven provinces with EDL less than 0.50. The province with the highest rural EDL was Beijing, followed by Shanghai. Jilin, Liaoning, Shaanxi, and Zhejiang were another four provinces with EDL greater than 0.60, at 0.64, 0.62, 0.61 and 0.61, respectively.

The provincial urban-rural EII in the eastern and northeastern regions are lower than that in the central and western regions (Fig. 3c). In 2003, the province with the lowest EII was Beijing, followed by Shanghai and Liaoning. On the other end of the spectrum were three provinces in southwest China, including Guizhou, Guangxi and Yunnan. In 2019, there were eight provinces with an EII below 0.90, the lowest of which was Jilin, followed by Beijing; Shaanxi and Shanxi were the other two provinces with an EII below 0.85, both at 0.83. The three provinces with an EII above 1.00 were Xinjiang, Tibet and Jiangsu, with values of 1.04, 1.02 and 1.01, respectively.

Additionally, the average annual change rates of provincial urban/rural EDL and EII were analyzed (Fig. 4). From 2003 to 2019, the average annual growth rate of urban/rural EDL is the fastest in western China and the slowest in northeastern China. In terms of the annual average decline rate of EII, the west is the fast, while the northeast is the slowest. Specifically, the average annual growth rate of urban EDL in nine provinces is less than 3.0%, with Hunan and Jilin being the lowest; only three provinces have an average annual growth rate greater than 4.0%, including Tibet, Gansu, and Yunnan. Nine provinces have an average annual growth rate of rural EDL below 5.0%, of which only Shanghai is lower than 4.0%, with a value of 3.83%; six provinces have an average annual growth rate exceeding 7.0%, of which Guizhou, Tibet and Yunnan in southwestern China are greater than 8.0%, reaching 8.60%, 8.53% and 8.06%, respectively. There are six provinces seeing their EII decline at an average annual rate of more than 3%, with Guizhou being the fastest, followed by Yunnan and Guangxi; and eleven provinces see an average annual decline of less than 2%, with Shanghai, Inner Mongolia and Heilongjiang being the three slowest provinces.
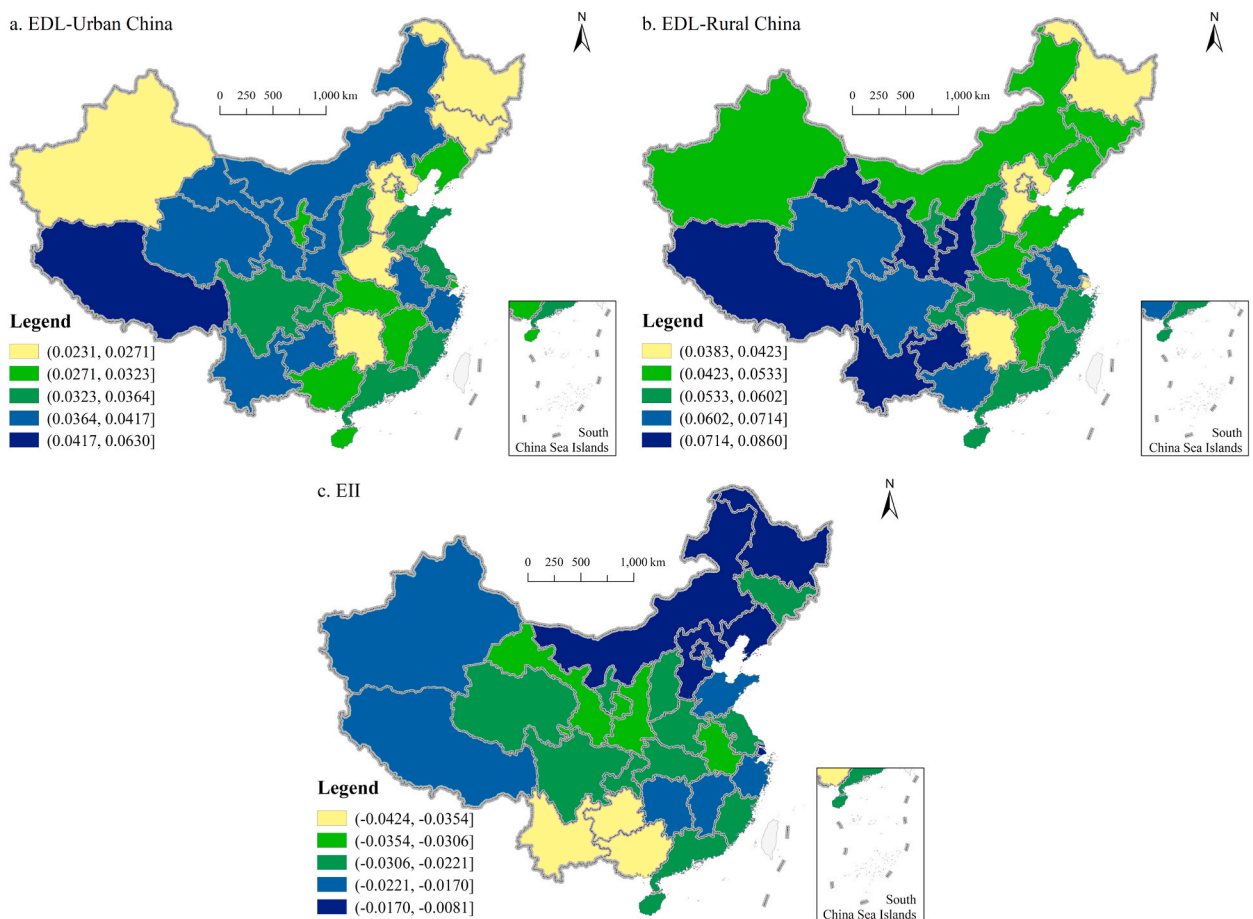

Fig. 4. Spatial pattern of average annual growth rate of provincial urban/rural EDL and EII in 2003–2019.

4.2. Regional inequalities of urban and rural educational development in China

Employing formulas (5) and (6), the CV and Theil index of provincial urban/rural EDL and EII were calculated to reveal the regional inequalities in China's urban and rural educational development. The results show that these indices generally presented a downward trend from 2003 to 2019, indicating that the regional disparity in urban/rural educational development is narrowing (Fig. 5). Compared with the continuously declining EII, the CV and Theil index of urban/rural EDL increased slightly in 2003–2006 and then continued to decline, with only rural EDL increasing in 2010–2011. That is, the regional gap in urban/rural educational development generally showed a trend of increasing and then decreasing. In terms of the difference between urban and rural areas, the CV and Theil index of rural EDL are greater than those of urban EDL, which means that rural inequality in educational development is more prominent than urban inequality.

Based on the division of China's four economic regions, formula (7) was further employed to decompose the Theil index to characterize provincial inequality in urban/rural EDL and investigate the contribution of intra- and inter-regional inequalities in urban/rural educational development to the national inequality (Fig. 6). The results indicate that the contribution of intraregional inequality to national inequality is greater than that of interregional inequality, showing an upward trend. Thus, it can be considered that the regional disparity in China's urban/rural EDL mainly comes from the disparity in urban/rural EDL within the region. Specifically, the contribution of intraregional inequality in urban EDL to national regional inequality in urban EDL increased from 60.33% in 2003 to 61.58% in 2004, then decreased to 51.00% in 2011, and increased to 63.69% in 2019; while the contribution of intraregional inequality in rural EDL to national regional inequality in rural EDL increased from 55.40% in 2003 to 59.61% in 2006, then decreased to 52.45%, and increased to 69.72% in 2019. Accordingly, the contribution of intraregional inequality in EII to national regional inequality in EII fluctuated from 61.31% in 2003 to 85.38% in 2010, then decreased to 74.67% in 2015 and continued to rise to 85.44% in 2019.

Further, the Theil index of urban/rural educational development in the four economic regions was also measured (Fig. 7). From 2003 to 2019, most of these indices are small and show a decreasing evolutionary trend, indicating that the inequality of educational development between regions is small and the gap between provincial educational development within regions is narrowing. Theil indices of urban/rural EDL in the eastern and western provinces of China continues to decline after a brief rise at the beginning of research period; these indices are small in central and northeastern China and presented a slow downward trend. The Theil index of EII does not differ much among the four economic regions, but there are differences in its evolutionary trends. Specifically, the Theil index of EII shows a fluctuating decreasing trend in eastern, central, and western China, while it shows a general increasing trend of rising, then falling, then rising again in northeastern China.

4.3. Mechanism of regional inequality in China's urban/rural educational development

To play the role of agriculture in providing original capital accumulation for industrial development, the Chinese government established an urban-rural dual structure through a series of institutional arrangements at the beginning of the founding of PRC, which led to a growing problem of inequality between urban and rural education [15,50]. After the reform and opening-up in 1978, great achievements have been gained in rural education due to the rapid economic development, but the gap between urban and rural educational development is still remarkable. Affected by the unbalanced development strategy, regional inequalities in urban/rural educational development have also become increasingly prominent. In the 21st century, the focus of domestic reform expanded to the social field [51–53], and regional and urban-rural relationship continued to be optimized and adjusted, helping to reduce the urban-rural gap in educational development and the regional inequality in urban/rural educational development (Fig. 8).

Firstly, industrialization is the basis for a sustained reduction in the regional inequality of educational development. Essentially, industrialization is the process of transformation from an agrarian to an industrial society [54]. A high level of industrialization means a high level of economic development in a region, and its ability to allocate educational resources to both urban and rural areas is also stronger, thereby promoting urban and rural educational development. Employing the growth rate of per capita GDP to feature the pace of industrialization, it is evident that the per capita GDP in China's provinces got a rapid increase in 2003–2019, and the average annual growth rate of per capita GDP in central and western regions was significantly faster than that in the eastern and northeastern
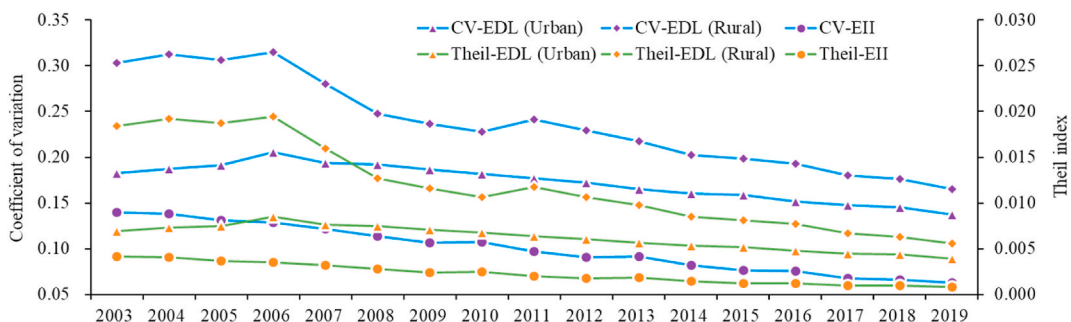

Fig. 5. Evolution of the regional inequality in China's urban/rural educational development from 2003 to 2019.
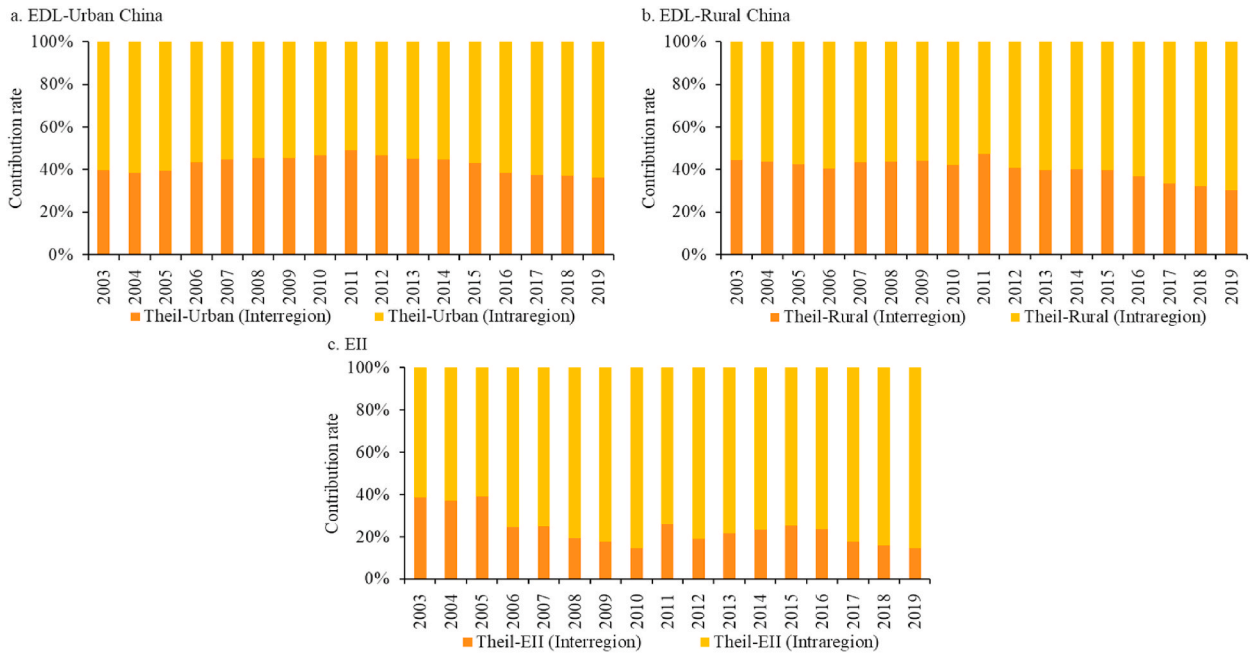
Fig. 6. Decomposition of the Theil index in China's urban/rural educational development from 2003 to 2019.
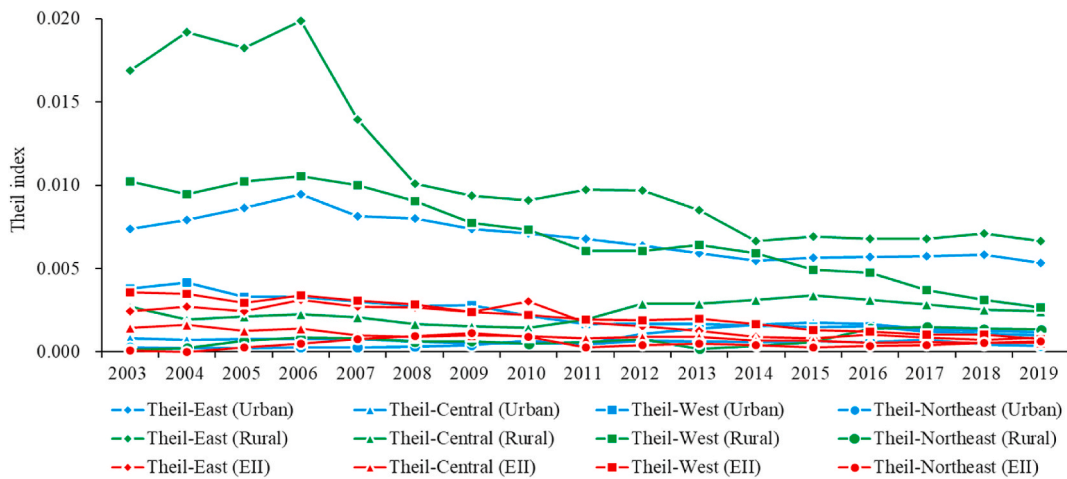

Fig. 7. Theil indexes for urban/rural EDL and EII in the four economic regions from 2003 to 2019.

regions (Fig. 9), which laid a solid economic foundation for the central and western regions to narrow the urban/rural educational development gap with the eastern regions.

Rapid industrialization inevitably leads to large-scale urbanization, which implies a massive migration of rural population to urban areas, including young and middle-aged laborers as well as their children. In this context, the urban school-age population is increasing rapidly, and the rural school-age population continues to decline. Thus, urban educational resources need to be shared by more school-aged population, while rural educational resources serve less and less targets. Although children of migrant workers used to be excluded from the urban public education system since they did not have an non-agricultural *hukou*, such restriction is being gradually removed as the *hukou* system reform deepens to ensure that children of migrant workers have equitable access to education in cities [28,55,56]. In 2014, the National New-type Urbanization Plan (2014–2020) proposed to actively promote the transformation of basic public services in urban areas from being provided mainly to registered population to being provided mainly to residential population, and to gradually solve the problem of basic public service for the population migrating in cities and towns. This change guarantees that children of migrant workers can enjoy equal rights to education in urban areas. According to available data, the number of children of migrant workers in compulsory education increased from 9.97 million in 2009 to 14.30 million in 2020, with the proportion of them attending public schools remaining at around 80%. In line with the needs of industrialization and urbanization, the Chinese
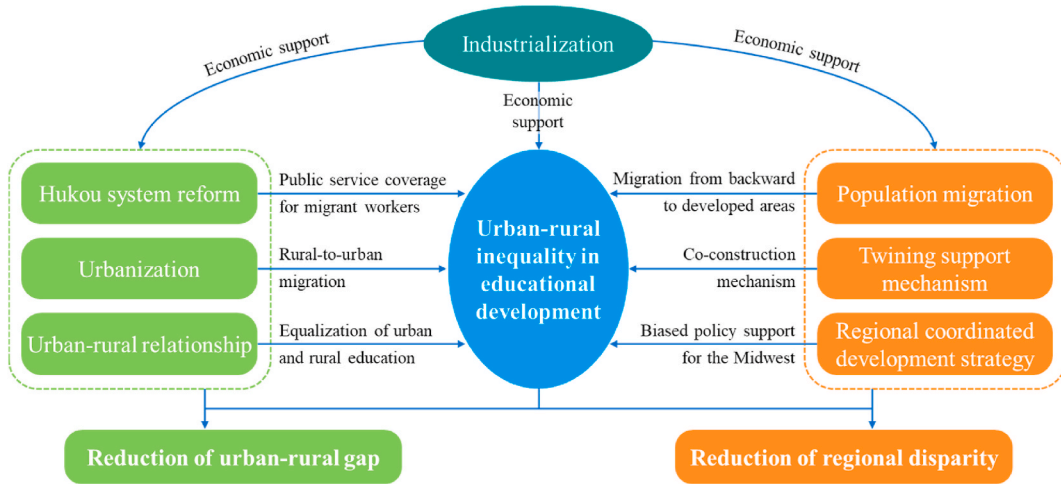
Fig. 8. The mechanism of regional inequality in China's urban/rural educational development.
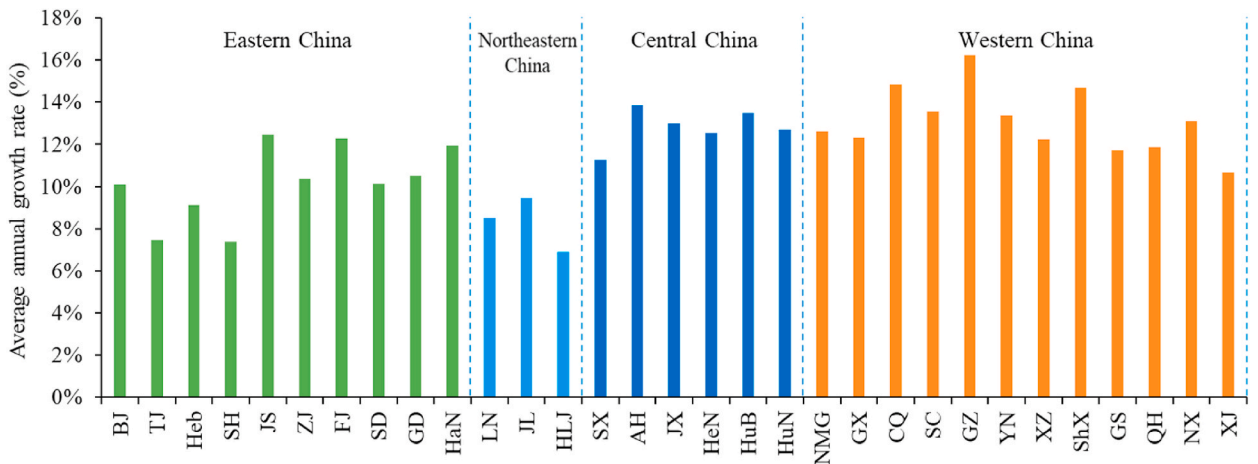

Fig. 9. Average annual growth rate of per capita GDP in China by province from 2003 to 2019.

government actively promotes the implementation of major strategies such as new socialist countryside construction and rural revitalization, and continuously optimizes and adjusts urban-rural relationship. From "balancing urban and rural development" to "promoting the integration of urban and rural development" and then to "urban-rural integrated development", the system of urban-rural dual structure is gradually broken to accelerate the formation of a new industrial-agricultural and urban-rural relationship featured by mutual promotion, urban-rural complementarity, coordinated development and common prosperity. Under the promotion of a series of rural-bias policies and measures, the shortcomings of China's rural educational development have been continuously made up, and great progress has been made in the equalization of basic public education services between urban and rural areas.

At the regional level, the spatial heterogeneity of natural and human conditions and unbalanced development strategies determine regional inequalities in economic development, causing a large population to migrate from central and western regions to eastern regions [57], which eases the supply pressure on educational resources in the central and western regions but exacerbates that in the eastern regions. To address economic inequality and its socio-economic problems, China vigorously promotes regional coordinated development, proposing major strategies such as western development and the rise of central China, while supporting the accelerated development of special regions such as old revolutionary bases, ethnic areas, and frontier areas. Therefore, a series of educational development policies and measures tilted toward the central and western regions were introduced. For example, in 2004, China launched the plan of "two basics (basically universalizing nine-year compulsory education and basically eliminating illiteracy among young and middle-aged people)" for the western region, and the central government arranged 10 billion yuan to implement the construction project of rural boarding schools in the western region; in 2016, the document of "Guidance on Accelerating Educational Development in Central and Western Regions" was issued to provide a top-level design for educational reform and development and promote the equitable educational development in the central and western regions. Additionally, a relatively stable co-construction mechanism between educationally developed and underdeveloped regions has been established through the form of twinning

support, which has effectively narrowed regional gap in educational development. Driven by propensity policies, the urban/rural EDL in the central and western regions grows faster than that in the eastern and northeast regions, and their urban-rural EII declines faster than that in the eastern and northeast regions.

5. Discussion

5.1. Suggestions for China's urban and rural educational development

Education is a major issue related to people's livelihood and national development [58,59]. In the 70 years since the founding of the PRC, China has built the largest educational system in the world and transformed from a country where nearly 80% of the population is illiterate to a country where basic education is universal [60]. However, it is important to note that inequality in educational development will shift from quantitative gap to qualitative difference when educational coverage reaches a certain high level [61]. On the other hand, China is still in a period of rapid urbanization [62], and rural-urban migration is the main direction of population movement at present and for a considerable period in the future. Under the circumstance that urban-rural dual structure has not been fundamentally eliminated, the inefficient use of rural schools and overloaded urban schools coexist [63,64], and the social integration of migrant workers still faces many obstacles such as children's education [65]. Additionally, in the context of socio-economic transformation and the continuous improvement of people's living standards, people's educational demand is no longer limited to "having a school to go to" and adequate educational resources, but more concerned about "having a good school to go to" and allocating good educational resources. Thus, innovating initiatives to promote the balanced and coordinated development of urban and rural education and build a high-quality educational system is important to meet people's aspirations for a better life and solidify the support for new-type urbanization and rural revitalization in the new era.

First, it is necessary to optimize the allocation of educational resources between urban and rural areas. Against the background of continued rural-to-urban migration, rural schools generally face a shortage of students, especially those in remote areas, resulting in a waste of educational resources, while urban schools the constant expansion of urban schools leads to a widespread problem of oversized classes. Therefore, the government should coordinate the financial investment in urban and rural education to ensure the educational needs of rural students as well as providing sufficient educational resources for the urban school-age population, achieving the unity of efficiency and equity.

Second, the government should actively promote the construction of educational informatization. The serious imbalance between urban and rural quality educational resources in China has long been a problem. To reverse this situation, the government should rely on the popularity of the Internet to actively promote "full coverage of broadband in all schools" and develop the "Internet + education" system. Through various forms such as urban-rural synchronous classroom and famous teacher online classroom, a digital education sharing platform is built to promote the sharing of high-quality educational resources between urban and rural areas and continuously narrow the gap between urban and rural education.

Third, the mechanism of twinning support needs to be improved. Based on the existing twinning support between developed and underdeveloped areas, local governments should also coordinate high-quality educational resources and further improve the twinning support mechanism in the region. Through various ways such as support teaching, walking teaching, and sending teaching to the countryside, a pattern of urban model schools helping weak schools in rural areas, central elementary school in townships helping external teaching sites, and strong schools helping poor schools will been formed.

Finally, more attention should be paid to promote *hukou* system reform. Since social welfare arrangements such as education are closely related to resident status, the *hukou* barrier between urban and rural areas is one of the important root causes of the unequal educational development between urban and rural areas. In this context, it is necessary to further deepen *hukou* system reform and return it to its most essential function of registering basic information of citizens. At the same time, it is worthy comprehensively sorting out and stripping off the benefits and constraints attached to the *hukou*, achieving full coverage of rights and interests of resident population such as education as well as balanced and universal access to basic public services in the place of residence.

5.2. Policy implications for reducing global educational inequality

Education is the key to achieving other SDGs [66]. In underdeveloped countries, poor educational systems and prominent educational inequalities reduce social mobility, leading to intergenerational transmission of poverty and a vicious cycle of education-poverty [67,68]. After decades of efforts, great progress has been made in reducing global educational inequality, including increasing access to education and school enrollment rates at all levels, particularly for girls. However, these achievements lack solid support. Emergencies such as COVID-19 pandemic and geopolitical conflicts have set back global educational development achievements by years or even decades, especially in sub-Saharan Africa and South Asia, bringing a great challenge to the achievement of the 2030 SDGs [69,70]. China has developed a path with Chinese characteristics aimed at reducing educational inequalities through rapid industrialization and urbanization as well as institutional reforms and policy innovations, providing valuable experiences and important impetus for promoting educational equity in the world.

First, underdeveloped countries should actively promote industrialization to promote economic development and strengthen the basic support for educational development. Insufficient investment in education due to poverty is an important reason for the lagging development of education in underdeveloped countries [71,72]; while the backwardness of education restricts the improvement of economic development level, forming a vicious cycle of poverty and educational backwardness. To reverse this situation, underde-veloped countries should focus on economic development, concentrate resources to develop economic production, improve the level of

industrialization, and then enhance their abilities to supply educational resources. Meanwhile, educational development promotes regional economic development to a higher level by improving the quality and quantity of human capital, forming a positive interaction between economic development and educational development.

Second, underdeveloped countries should actively promote urbanization to achieve the agglomeration of factors such as population and improve the utilization efficiency of educational resources. Due to the low level of economic development, underdeveloped countries have limited educational resources at their disposal. However, the situation that the population is widely spread over vast rural areas has led to common problems of low enrolment rates and high dropout rates [73]. In this context, to maximize the performance of limited educational resources, it is necessary to promote population agglomeration in urban areas and optimize the allocation of educational resources. On the other hand, as a process of spatial concentration of population, technology, information and other factors driven by industrial agglomeration [74], urbanization is conducive to exerting the economy-of-scale of educational resources and improving the utilization efficiency of educational resources.

Third, underdeveloped countries should strengthen the practice of South-South and North-South cooperation in the field of education to promote the sharing the educational resources. In the context of globalization, how to use the external resources to promote socio-economic development has been an important issue for underdeveloped countries. As two important ways for underdeveloped countries to utilize external resources, South-South and North-South cooperation focus on fields such as economy and technology [75–77]. Although exchanges and cooperation in the fields of educational development and human resources are involved, the overall scale is limited. Thus, underdeveloped countries need to strengthen their educational cooperation with developed countries and developing countries with advantages according to their own characteristics, make full use of external resources to make up for the shortcomings in educational development, and improve the level and quality of educational development.

6. Conclusions

As a complex social phenomenon, absolute educational equality does not exist, and educational inequality is a universal reality that human societies are bound to face. For a long time, China's urban-rural dual structure combined with unreasonable institutional design has led to an extremely prominent urban-rural gap in educational development and significant regional differences in urban/rural educational development. Since 2003, under the influence of rapid industrialization and urbanization as well as *hukou* system reform and regional coordinated development strategy, the gap between urban and rural educational development in China is rapidly declining and the regional differences in urban/rural educational development are shrinking. Specifically, urban/rural EDL in China increased from 0.29 to 0.22 in 2003 to 0.47 and 0.54 in 2019, respectively, with a corresponding decrease in EII from 1.31 to 0.92. Spatially, the provincial urban/rural EDL in the eastern and northeastern regions is significantly higher than that in the central and western regions, but the average annual growth rate is significantly slower than that in the central and western regions; urban-rural EII in the eastern and northeastern regions is significantly lower than that in the central and western regions. The decreasing CV and Theil index indicate that regional disparities in urban/rural EDL are narrowing and that regional inequality in rural EDL are more prominent than that in urban areas. The decomposition of Theil index presents that the inequality of EDL at the national level mainly comes from the disparity of urban/rural EDL within regions, in which the contribution rate of intraregional urban/rural educational development inequality to national educational development inequality increased from 60.33% to 55.40% in 2003 to 63.69% and 69.72% in 2019, respectively. To promote the coordinated development of urban/rural education in China, it is necessary to further optimize the allocation of urban and rural educational resources, promote the development of "Internet + education", improve the twinning support mechanism, and deepen *hukou* system reform. China's practice shows that underdeveloped countries should actively promote industrialization and urbanization and strengthen action plans on education in South-South cooperation and North-South cooperation, so as to improve their EDL and consolidate their human capital support to realize the SDGs.

Educational inequality is a complex social phenomenon. However, when selecting specific indicators, we mainly consider the quantity of educational opportunities, and do not pay enough attention to indicators that reflect the quality of educational opportunities, such as teachers' teaching skills, and the educational outcomes, such as students' abilities. At the same time, this study focuses on primary and secondary schools, excluding pre-primary education and higher education. When investigating the mechanism behind urban/rural inequality in educational development, we mainly explore them qualitatively and lack quantitative analysis. In the future, it is necessary to further strengthen the acquisition of data on educational outcomes, pre-primary education, and higher education to fully explore the phenomenon of urban-rural educational inequality and use various quantitative analysis methods such as econometric models and spatial statistics to diagnose the factors influencing urban-rural educational inequality.

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Data availability statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

CRediT authorship contribution statement

Yuanzhi Guo: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources,

Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Xuhong Li:** Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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