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EXPLORING THE DIVERSITY OF HIGHER EDUCATION RESOURCE ALLOCATION IN CHINA EXPLAINED BY THE GINI COEFFICIENT

Dandan Shen[1,2,*] and Fan Xia[2]

[1]School of Computer Science and Intelligence Education
Lingnan Normal University
No. 29, Cunjin Road, Chikan, Zhanjiang 524048, P. R. China

[2]Doctoral Program of Educational Leadership and Technology Management
Tamkang University
No. 151, Yingzhuan Road, Tamsui District, New Taipei City 251301, Taiwan
xia.xiang@aliyun.com
*Corresponding author: 808764020@gms.tku.edu.tw

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Abstract. *Promoting higher education development has become an emerging task in various countries. China has persisted in investing in higher education to face global competition. However, the issue of equal resource allocation for higher education continues to cause public concern. China initiated a mid- and long-term education reform and development planning guideline for 2010-2020. It is the main project for promoting education quality and equality of resource allocation. Taking China as an example, this study conducted a systemic review of the resource issue in the higher education system. We employed a fuzzy expert questionnaire and data transformation to select the fitted indicators. The selected 11 indicators were used to transform the data from the Ministry of Education, China. The Gini coefficients were used to evaluate the equality of resource allocation among provinces in the whole country and in different areas. During the project implementation (2015-2019), the effect of resource allocation displayed by the Gini coefficient is smooth. The findings suggest that the equality of resource allocation in the higher education system is acceptable except for in the western areas. This evidence-based study may provide useful information for related policy makers.*
Keywords: Equality of education, Fuzzy statistics, Gini coefficient, Higher education, Resource allocation

1. **Introduction.** Adequate and sustained resources have become critical issues to achieve the goals of university in contemporary higher education [1]. However, inadequate funding has become one of the most important challenges that should be faced in universities. For example, decreasing government funding may create a financially constrained environment in universities [2]. Considering the ubiquity of higher education institutions and the variety of operational strategies, the resource allocation remains a persistent issue in contemporary higher education systems.

Previous studies argued that state-level resource allocation policies can be created to distribute resources in a manner that provides equal educational opportunities for all students. Reasonable resource allocation aligns with the state's constitutional obligation which can provide equality of educational opportunity, particularly for students living in poverty [3]. Zhang et al. found that enrollment quota was a special resource, and a more reasonable allocation scheme was conducive to solving the problem of unbalanced development of higher education among provinces [4]. Yu et al. believed that universities should have a reasonable scale, establish a system of paid occupation of resources, and build an

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effective cost accounting system [5]. Ates suggested giving full financial autonomy to the administrations of higher education institutions and to establish an autonomous structure that can realize this, to distribute resources to higher education institutions in "blocks", and to establish an autonomous higher education financial audit system [6]. The Chinese government is implementing performance-based funding as the primary funding method [7]. Moreover, dissemination of higher education and increasing participation rates have become political agendas. In recent years, higher education systems in Europe, the rapid increase in student enrollment, a relative decline in public finances as well as a shortage of private funding have led to increasing pressure on innovation and research in the global and knowledge-based economy [8]. Resource allocation and funding in higher education has become one of the crucial components of the success of reform and transformation of higher education systems [9,10]. These studies have provided references for how to allocate education resources, but lack new perspectives. In China, the national long-term policy has indicated that promoting equality is a basic policy for all levels of education. Adequate resource allocation for diminishing the education gap is essential [11], and the Gini coefficient presents a more academic perspective to explain the unbalanced distribution of education resources [12]. Therefore, it is necessary to use the Gini coefficient to analyze the relevant data in recent years to explore the diversity of higher education resource allocation in China.

China initiated a mid- and long-term education reform and development planning guideline for 2010-2020. The major higher education policies included lifting higher education massification, promoting resource allocation, and reasonable guidance and classification of higher education institutions [11]. Ten years later, it is time to review the effectiveness of the policy implementation. Considering the geographic area, China has shown an imbalance in her economic and social development [13]. Typically, the economic development in the eastern area is better than that of the central and western areas [14]. In this sense, this experience might directly reflect higher education resource allocation. Previous studies argued that an unbalanced environment may cause resource allocation issues in higher education [15,16]. For example, the level of per student expenditure is impacted by the budget constraints of the specific local governments [17], and the regional investment differences will widen the education gap between provinces [18]. The problem is that the phenomenon of unbalanced resource allocation continues to exist and has become a long-term issue. This study assumes that the provinces and cities may play key roles in reallocating higher education resources. We should not only pay attention to the resource allocation among the provinces of the country, but also focus on the diversity among the provinces within a certain area. The study developed fitted indicators for resource allocation and employed the official data set in China from 2015 to 2019 to explore the issue. This study aimed to identify the problems in higher education resource allocation through scientific research methods, so as to provide the basis for policy makers to make policies. Basically, human, physical, and financial resources are essential components of university management. We consider that the resource allocation issue will focus on these areas. Specifically, the research purposes are listed as follows:

a) Defining the fitted indicators for resource allocation in higher education;
b) Detecting the issues of higher education resource allocation within provinces;
c) Specifying the issues reflected from resource allocation indicators for areas.

The remaining parts of the paper will be presented as follows. First, we will address the logic of selecting the indicators, and the data collection and data transformation procedures in the method section. Then, the result of the Gini coefficient among provinces in the whole country and in different areas will be discussed. Finally, the conclusions will be drawn, and related suggestions will be presented.

2. **Method.** In this study, the diversity of higher education resource allocation was evaluated on the basis of province. Considering the evaluation system, we selected the fitted indicators according to experts' views. In the following section, we address the logic of indicator selection, data collection, and how the Gini coefficients of the indicators were computed.

2.1. **Selection of resource allocation indicators.** This study invited 10 experts in higher education to participate in the selection of the fitted resource allocation indicators. The selected indicators were based on the experts' views on the importance of the indicators to evaluate the diversity in China's higher education. The invited experts were asked to express their views on a 0-7 fuzzy interval scale with those candidate indicators. This study employed fuzzy interval data which transformed the experts' view into fuzzy mean and centroid formats. The concept of interval fuzzy data can be defined as a distributed membership function with fuzzy numbers. If $[a, b]$ is an interval fuzzy set, we can define $C_o = (a + b)/2$, $S_o = (b - a)/2$; they represent the "centroid" and "radius" or "variance" respectively [19-22]. Based on the results of the experts' views, this study selected 11 indicators in the human resource (H), physical resource (P), and financial resource (F) domains. Table 1 demonstrates the selected indicators with fuzzy means and fuzzy centroids by calculating the view of the importance of educational resources with all experts. The centroids of the selected indicators are larger than 5.00.

Table 1. Selection of resource allocation indicators with fuzzy means and centroids

Domain	**Indicator**	**Fuzzy mean**	**Centroid**	**Radius**
Human resources	H1: Student enrollment	$[5.66, 6.78]$	6.22	0.56
	H2: Number of full-time faculties	$[5.56, 6.52]$	6.04	0.48
	H3: Number of faculties with a doctoral degree	$[4.45, 5.66]$	5.06	0.61
	H4: Number of senior faculties	$[4.45, 5.56]$	5.01	0.56
Physical resources	P1: Campus space	$[4.64, 5.64]$	5.14	0.50
	P2: Number of books	$[4.49, 5.86]$	5.18	0.56
	P3: Number of computers	$[5.58, 6.69]$	6.14	0.56
	P4: Internet and multimedia resources	$[5.48, 6.35]$	5.92	0.44
Financial resources	F1: Average educational expenditure on higher education	$[5.56, 6.64]$	6.10	0.54
	F2: Per student expenditure of public finance budget for higher education	$[5.45, 6.73]$	6.09	0.64
	F3: Per student of average public expenditure	$[4.72, 6.23]$	5.48	0.76

2.2. **Data collection.** Due to the lack of data for some indicators from 2010 to 2014, this study employed 11 indicators to transform resource allocation data from the Ministry of Education and China Educational Finance Statistical Yearbook 2015-2019 [23,24]. However, the data of average educational expenditure on higher education (F1) in 2019 will not be published until the end of 2021. Each indicator covered the resource allocation of 31 provinces (including 4 municipalities and 5 autonomous regions). According to the level of economic development, China's provinces can be divided into three areas. The eastern area, also known as the coastal area, consists of 12 provinces: Liaoning, Hebei, Beijing, Tianjin, Shandong, Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong, Hainan, and Guangxi. The central area includes nine provinces: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan. The western area includes 10 provinces, namely Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Chongqing, Sichuan,

Guizhou, Yunnan, and Tibet. In order to explore the status of higher education resource allocation in these different areas, the data of the 11 indicators were reclassified with Gini coefficients according to the eastern, central, and western areas of China.

2.3. **Computing the Gini coefficients.** The Gini coefficient (also called the Gini index or Gini ratio) was originally a statistical measure of economic inequality in a population. The coefficient measures the dispersion of income or distribution of wealth among the members of a population [25]. The coefficient can take any value between 0 and 1 (or 0% to 100%). In general, a Gini coefficient below 0.2 means high equality, 0.2-0.3 means moderate equality, 0.3-0.4 means bearable, 0.4-0.6 means moderate inequality, and above 0.6 means high inequality [26]. In this study, we extended the basic concept of the "income" Gini coefficient to measure the "resource allocation inequality" between resource-rich provinces and resource-poor provinces. This study transformed the original data from 31 provinces in China to analyze the Gini coefficients of human resources, physical resources, and financial resources in higher education.

The Gini coefficient is defined as a ratio of the areas on the Lorenz curve diagram. If the area between the line of perfect equality and the Lorenz curve is A, and the area under the Lorenz curve is B, then the Gini coefficient is $A/(A+B)$. Since $A+B=0.5$, the Gini coefficient, $G=2A=1-2B$ [27] (see Figure 1).

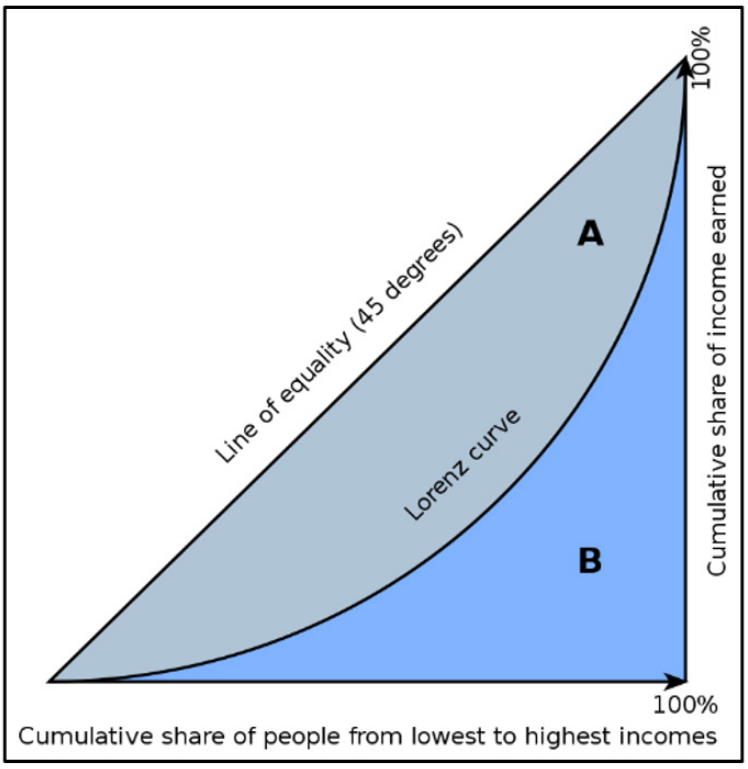

FIGURE 1. The calculation of the Gini coefficient

The measure can be applied to calculating the Gini coefficient, without direct reference to the Lorenz curve. If the Lorenz curve is approximated on each interval as a line between consecutive points, then the area B can be approximated with trapezoids and

$$G = 1 - \sum_{k=1}^{n} (X_k - X_{k-1})(Y_k + Y_{k-1})$$

is the resulting approximation for G [27]. For example, X refers to the share of people from lowest to highest incomes, and Y refers to the share of income earned.

3. **Results.** This section will address the transformation of Gini coefficients with human, physical, and financial resource allocation based on provinces and the three different areas of China. The Gini gap among the indicators will be displayed as follows: Sub-section 3.1 presents the Gini coefficients of H1, H2, H3, and H4 indicators from 2015 to 2019, showing the diversity of human resource allocation in China. Sub-section 3.2 illustrates the Gini coefficients of physical resource allocation in P1, P2, P3, and P4 within 5 years. Sub-section 3.3 demonstrates the Gini coefficients of financial resources allocation in F1, F2, and F3.

3.1. **Human resource allocation.** Figure 2 reveals the related human resource allocation among 31 provinces. From 2015 to 2019, the changes in the Gini coefficient with the human resource allocation were very small. Among the 31 provinces, the Gini coefficients of H1, H2, and H4 are less than 0.4. This implies that the distribution of student enrollment, full-time faculty, and senior faculty are alike nationwide. However, H3 shows the Gini from 0.4216 to 0.4382 during 2015-2019, which reflects that the faculty with a doctoral degree had much more diversity.

Comparing the area differences, the results revealed that the western area has shown wide diversity in its human resource allocation. Student enrollment, number of full-time faculties, number of faculties with a doctoral degree, and number of senior faculties all had larger Gini coefficients during 2015-2019; see Table 2. The relatively large Gini coefficients

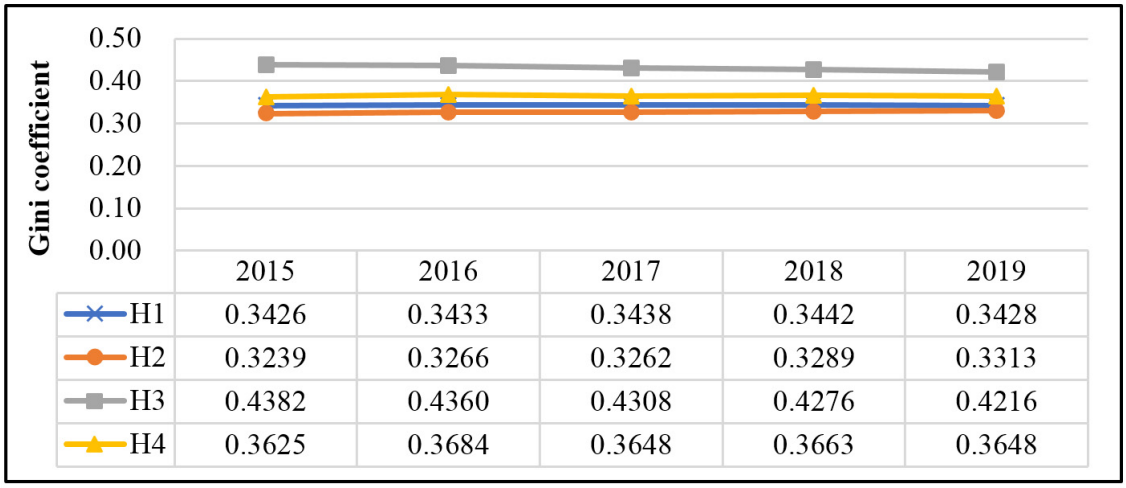

FIGURE 2. Gini coefficients of human resource allocation in higher education among 31 provinces

TABLE 2. Gini coefficients of human resource allocation based on areas

Areas	Indicators	2015	2016	2017	2018	2019
Eastern	H1	0.3014	0.3064	0.3084	0.3081	0.3075
	H2	0.2670	0.2712	0.2712	0.2722	0.2710
	H3	0.3511	0.3511	0.3436	0.3407	0.3363
	H4	0.2880	0.2997	0.2935	0.2947	0.2911
Central	H1	0.2221	0.2256	0.2339	0.2436	0.2465
	H2	0.2074	0.2145	0.2215	0.2282	0.2371
	H3	0.2707	0.2680	0.2654	0.2593	0.2515
	H4	0.2203	0.2246	0.2238	0.2221	0.2212
Western	H1	0.4443	0.4383	0.4320	0.4257	0.4202
	H2	0.4310	0.4319	0.4223	0.4247	0.4247
	H3	0.5231	0.5188	0.5137	0.5127	0.5109
	H4	0.4381	0.4384	0.4292	0.4365	0.4365

reflect the unequal distribution issue of human resource allocation in the western area. However, the results of Gini coefficients in the other two areas are within the range of 0.2-0.4, which provide substantial evidence for the more equitable human resource distribution. The result of economic development may impact human resource allocation in higher education. The findings suggest that the market will drive the mobility of students and faculty, and thus may worsen the unequal distribution within the west area. The result indicates the limitation of policy intervention in the National Mid- and Long-Term Education Reform and Development Planning Guideline 2010-2020 [11].

3.2. **Physical resource allocation.** Both Figure 3 and Table 3 demonstrate the Gini coefficients of physical resource allocation in P1, P2, P3, and P4. The results (Figure 3) reveal that the Gini coefficients among the indicators are between 0.3 and 0.4, and they are smooth from 2015 to 2019. The physical resource allocation in higher education tends to be relatively equivalent among the 31 provinces. Comparing the areas, this study found that the results of physical resource allocation are different in the western area (highest

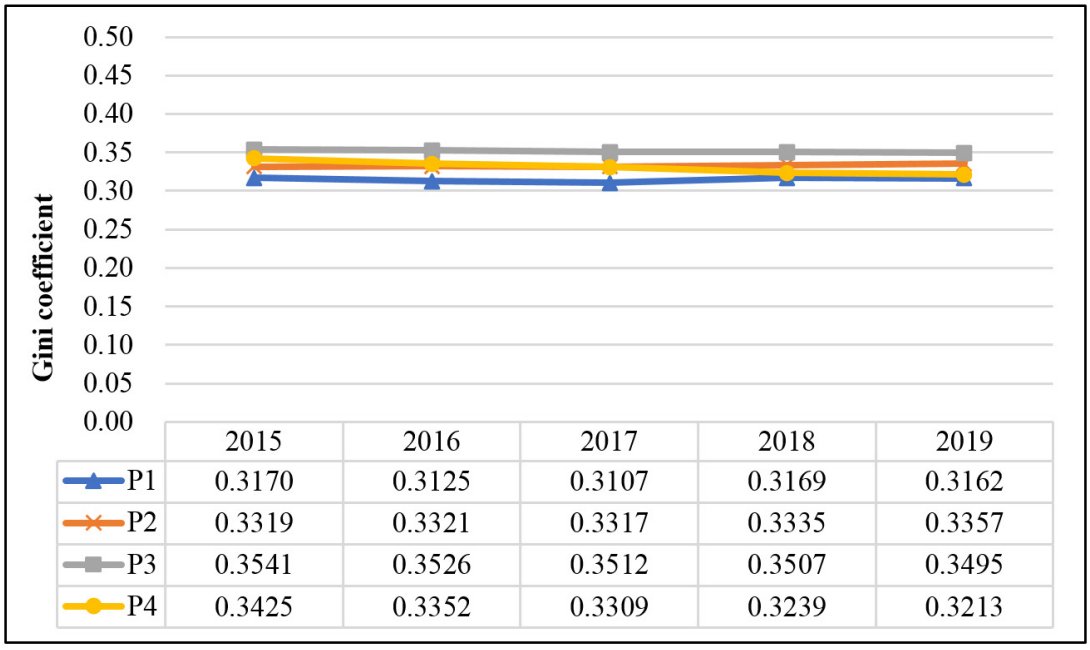

FIGURE 3. Gini coefficients of physical resource allocation in higher education among 31 provinces

TABLE 3. Gini coefficients of physical resource allocation based areas

Areas	Indicators	2015	2016	2017	2018	2019
Eastern	P1	0.2960	0.2955	0.2927	0.2922	0.2905
	P2	0.2628	0.2652	0.2672	0.2682	0.2672
	P3	0.2802	0.2824	0.2832	0.2813	0.2785
	P4	0.2939	0.2911	0.2948	0.2827	0.2854
Central	P1	0.2049	0.2028	0.2032	0.2098	0.2781
	P2	0.2185	0.2247	0.2263	0.2322	0.2371
	P3	0.2100	0.2105	0.2118	0.2173	0.2213
	P4	0.2431	0.2336	0.2351	0.2344	0.2380
Western	P1	0.3813	0.3727	0.3650	0.3921	0.3691
	P2	0.4451	0.4403	0.4337	0.4359	0.4384
	P3	0.4527	0.4426	0.4340	0.4343	0.4318
	P4	0.4298	0.4268	0.4087	0.4022	0.3897

Gini: larger than 0.4) and its counterparts (Gini: from 0.2 to 0.3). The results suggest that the government may need supportive strategies to improve the number of books, number of computers, and Internet and multimedia resources in specific higher education institutions in the western area. If the higher education institutions make full use of network technology to redistribute the electronic physical resources, the gap in physical resources between provinces, especially those in the western area, may be reduced [28].

3.3. **Financial resource allocation.** Both Figure 4 and Table 4 demonstrate the Gini coefficients of financial resource allocation in F1, F2, and F3. Gini coefficients (Figure 4) demonstrate that there are small fluctuations among the indicators from 2015 to 2019. Even though the Gini coefficients of the three indicators are less than 0.4, it reflects that the allocation of financial resources in higher education is relatively equal among the 31 provinces. We may indicate that the Gini coefficients of average educational expenditure on higher education (F1) from 2015 to 2018 tended towards 0.4. This may alert policy makers that they should consider this issue. Table 4 reveals that most of the indicators reflect the equality of financial resource allocation, while the Gini coefficients of average educational expenditure (F1) in the western area are larger than 0.4. The unequal allocation of average educational expenditure for students in the western area could be an

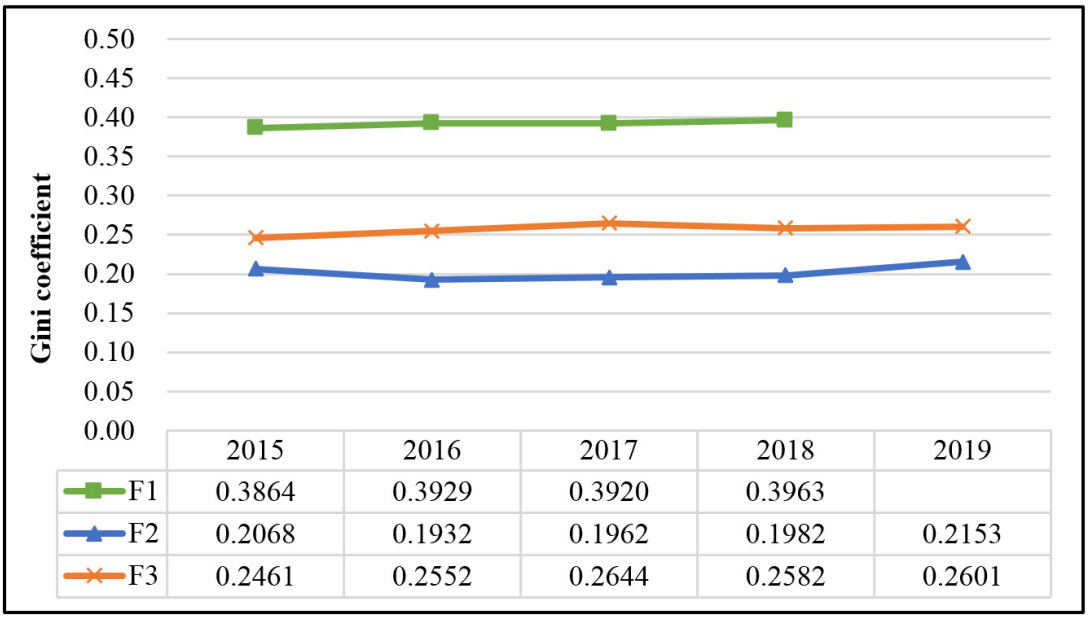

FIGURE 4. Gini coefficients of financial resource allocation in higher education among 31 provinces

TABLE 4. Gini coefficients of financial resource allocation based on areas

Areas	Indicators	2015	2016	2017	2018	2019
Eastern	F1	0.3256	0.3313	0.3324	0.3308	
	F2	0.2516	0.2305	0.2448	0.2355	0.2392
	F3	0.3081	0.2797	0.2912	0.2756	0.2535
Central	F1	0.2034	0.2057	0.2190	0.2239	
	F2	0.0987	0.0798	0.0630	0.0601	0.0662
	F3	0.1057	0.1027	0.1016	0.1096	0.1092
Western	F1	0.4349	0.4425	0.4308	0.4310	
	F2	0.1739	0.1759	0.1560	0.1823	0.2325
	F3	0.1776	0.2216	0.1932	0.2444	0.2940

emerging issue. Policy makers may need to rebalance the allocation of financial resources among the provinces in the western area [29].

4. **Conclusions.** Since 2000, China has consistently invested in higher education, especially focusing on promoting quality and equality on a nationwide basis. The government has initiated the National Mid- and Long-Term Education Reform and Development Planning Guideline from 2010 to 2020. This study employed Gini coefficients to evaluate the effect of policy intervention. The findings suggest that the diversity of most higher education resource allocation diminished after the policy was implemented. This study suggests that further intervention in resource allocation in higher education should consider the differences between provinces within areas. The lag of the western area in China should be taken into account in the government's new higher education policy.

We found that applying scientific approaches to exploring higher education issues is still very limited in China. This study provides a practical example of designing a fuzzy questionnaire to select the fitted resource allocation indicators to transform the official data set. This study demonstrates that the Gini coefficients can be used to properly evaluate the diversity of higher education resource allocation. The provinces in the whole country or in a certain area can be an optional issue classification for tackling a specific issue. The research design can be extended to solve similar issues in other settings. In the future, we can explore the reasons why there is still inequality in the higher education resource allocation in the aforementioned indicators (for example, Gini is larger than 0.4), and put forward some reasonable suggestions for education policy makers to improve the structure of higher education resource allocation.

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