Scale Evolution of Higher Vocational Education and Measurement of Education Opportunity Difference Based on the Expansion Effect

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Abstract—Scale expansion of higher vocational education requires scientific instructions, therefore figuring out the spatial and temporal evolution laws of higher education is a meaningful work for realizing the scale expansion of quality-oriented higher vocational education. However, existing studies have neither discussed the effect of such instructions on the rewards of higher vocational education, nor considered the comprehensive influence of the promotive and instructive effect of market-oriented and society-oriented employment of high vocational education on its heterogeneous rewards. To fill in these research blanks, this paper studied the evolution of the scale of higher vocational education and the difference in educational opportunities based on the expansion effect. At first, this paper constructed a scale expansion effect model of higher vocational education to explore the reward mechanism of scale expansion of higher vocational education in the labor market. Then, the paper distinguished the different levels of higher vocational education, and analyzed the evolution mechanism of the unfairness degree of students or workers acquiring different-level higher vocational education opportunities during the scale expansion process of higher vocational education. At last, the experimental results and analysis results were given.

Keywords—expansion effect, higher vocational education, scale expansion, evolution analysis, difference in education opportunities

1 Introduction

Expanding the scale of higher vocational education is an important measure stipulated by the *National Higher Vocational Education Reform Implementation Plan* issued by the Party Central Committee and the State Council of China. It is not only a major opportunity for the reform and development of higher vocational education, but also a respond to the actual needs of talents in modern society [1–8]. The scale expansion of higher vocational education has continuously increased the enrollment ratio of ordinary high school graduates, secondary vocational graduates, and social candidates, promoted the cultivation of applied talents with high quality and professional skills, solved

the problem of "structural unemployment", and provided sufficient manpower for the development of society and economy [9–18]. However, the scale expansion of higher vocational education requires scientific instructions to avoid ineffective low-density expansion, update high-quality educational resources and excellent faculty, and optimize the development space of higher vocational education. Therefore, figuring out the spatial and temporal evolution laws of higher education is a meaningful work for realizing the scale expansion of quality-oriented higher vocational education.

Lin [19] researched the influence of the scale expansion of higher vocational education on economic growth, the author used the Cobb-Douglas function to build a theoretical model and used it to analyze such influence. Gao [20] pointed out in his/her paper that the higher education in China has transformed from the elite stage to the popular stage in the past thirty years, the author summarized the features of the expansion of higher education, investigated the possible factors that might affect the higher education in China between 1978 and 2008, and found that historical value is the primary reason and the expansion of higher education is dependent. To figure out the factors affecting the scale expansion of higher educational institutions, Gao [21] adopted a correlation analysis method based on gross enrollment ratio, and the results suggest that the elite stage of higher education system is stable, and the number of teachers and enrolled students is the primary factor of the increase in the number of colleges and universities. In terms of education equity, Alonso-Ferreiro et al. [22] discussed a plan that promotes the digital competence of students in Galicia of Spain, the researchers selected 18 projects from 1100 public schools, and the survey results questioned the common principle of education equity in the public education system. In terms of the development of higher vocational education, Ren and Zhou [23] constructed a comprehensive evaluation index system based on the panel data from 2008 to 2020, and adopted a coupling coordination model to study the coupling and coordinating relationship between higher vocational education and regional economic development in the Yangtze River Economic Belt of China; their findings showed that in the past 13 years, the development levels of higher vocational education system and regional economic development system in the study region were on the rise, and the two systems are coupled.

A number of theoretical studies have proposed that that higher vocational education has a promotive and instructive effect on the market-oriented and society-oriented employment, but they didn't discuss the influence of such instructive effect on the rewards of higher vocational education, and few of them have concerned about the comprehensive effect of the two on the heterogeneous rewards of higher vocational education. To fill in the said research blank, this paper aims to explore the problem of how the scale expansion of higher vocational education exerts an impact on the rewards through two mechanisms of educational opportunity distribution and social classification, and this is the research focus of this paper. In the second chapter, the text constructed a theoretical model to describe the scale expansion effect of higher vocational education and explore the reward mechanism of the scale expansion of higher vocational education in the labor market. In the third chapter, based on the constructed model, the text distinguished the different levels of higher vocational education, and analyzed the evolution mechanism of the unfairness degree of students or workers acquiring different-level higher vocational education opportunities during the scale

expansion process of higher vocational education. In the fourth chapter, the results of experiment and analysis were given.

2 Modelling of the scale expansion of higher vocational education

The opportunity distribution of higher vocational education gains educational rewards by affecting the education, the supply and demand structures of different labor markets and the life opportunities have changed, so the stratification of society has been reshaped. To explore the reward mechanism of the scale expansion of higher vocational education in the labor market, this paper established an endogenous growth model that contains the educational choices of previous ordinary high school graduates, secondary vocational graduates, and social candidates as well as the allocation of highly-skilled labor force. In this model, according to the job position types, the rewards of higher vocational education are divided into management positions, common skill positions, and professional skill positions. For students or workers, the main reason for receiving higher vocational education or not is to expect to maximize the utilities of their own. However, due to the heterogeneity in the personal abilities of students, during the scale expansion of higher vocational education, it's necessary to form a stable opportunity distribution and functions of higher vocational education, thereby determining the rewards of higher vocational education at last. The settings of the model are detailed below.

Assuming: the rewards of higher vocational education are generated by the cooperation of different job positions, so the production function of the rewards of higher vocational education is constructed as follows:

$$B_o = K_o^{1-\beta} \int_0^1 X_{io}^{1-\beta} a_{io}{}^{\beta} c_i \tag{1}$$

where, B_o represents the final education reward; K_o represents the labor force quantity of management positions at time moment o; A_{io} represents the quantity of the i-th type of intermediate education reward at time moment o; X_{io} is the productivity parameter that measures the quality of the technical level or education reward of the i-th common skill position. The final education reward is standardized to 1, assuming JG_{io} represents the value of intermediate education reward a_{io}; θ_o^K represents the labor force salary rate of management positions, then the maximization of final education reward can be expressed as:

$$\max_{K_o, a_{io}} : K_o^{1-\beta} \int_0^1 X_{io}^{1-\beta} a_{io}{}^{\beta} c_i - \int_0^1 JG_{io} a_{io} c_i - \theta_o^K K_o \tag{2}$$

Based on the above expressions, there are:

$$\begin{aligned} \theta_o^K &= (1-\beta) K_o{}^{-\beta} \int_0^1 X_{io}{}^{1-\beta} a_{io}{}^{\beta} c_i \\ JG_{io} &= \beta K_o{}^{-\beta} X_{io}{}^{1-\beta} a_{io}{}^{\beta-1} \end{aligned} \tag{3}$$

Assuming: the intermediate education reward is attained by the final education reward 1:*k*, then the conditions for maximizing the intermediate education reward a_{io} is:

$$\max_{a_{io}} : \beta K_o^{-\beta} X_{io}^{1-\beta} a_{io}^{\beta} - a_{io} \tag{4}$$

Then we can get:

$$a_{io} = \beta^{\frac{2}{1-\beta}} X_{io} K_o \tag{5}$$

The corporate profit corresponding to a_{io} is:

$$\prod_{io} = \beta^{\frac{1+\beta}{1-\beta}} (1-\beta) X_{io} K_o \tag{6}$$

The above two formulas can be combined to define the growth rate of the entire higher vocational education rewards $X_o = \int_0^1 X_{io} d_i$, then the labor force salary rate corresponding to the final education reward can be calculated by the following formula:

$$\theta_o^K = (1-\beta)\beta^{\frac{2}{1-\beta}} X_o \tag{7}$$

Next, about the production process upgrading and product research and development activities of professional skill positions, for this type of position, attaining rewards from production activities is random, if there're attained rewards, then $X_{io} = \alpha X_{i(o-1)}$ (α>1), otherwise $X_{io} = X_{i(o-1)}$. Assuming: λ represents the probability for professional skill positions to attain rewards from participating in production activities; S_o represents the evaluation of the ability of worker who works at the professional skill position, then there is $\lambda = \mu S_o$. Assuming: the reward of the professional skill position for participating in production activities is obtained by the worker of this job position, then the salary rate θ_o^S for per unit ability of the professional skill position can be calculated by the following formula:

$$\mu S_o \int_0^1 \prod_{io} ci - \theta_o^S S_o = 0 \tag{8}$$

Namely:

$$\theta_o^S = \mu \int_0^1 \prod_{io} ci = \mu\beta^{\frac{1+\beta}{1-\beta}} (1-\beta) X_o K_o \tag{9}$$

Students or workers will choose whether to receive education or not based on the maximized utilities of their own, in this paper, the logarithm of their internship or work income is used to describe their personal utilities. If a student or worker with an initial personal ability of β_i chooses to receive the higher vocational education, his/her personal ability will be enhanced, assuming ξ represents the ability enhancement degree, and he/she assumes a professional skill position with a probability of $\chi(F)$, so the expected utility of a student or a worker receiving higher vocational education can be expressed as:

$$V_1 = \chi(F) log\theta_o^S(\beta_i + \xi) + (1 - \chi(F)) log\theta_o^K - \rho \log F \tag{10}$$

If a student or a worker chooses not to work in a job position without receiving the education, then his/her utility is:

$$V_2 = log\theta_o^K \tag{11}$$

When $V_1 = V_2$, we can get the critical individual ability node β^* for students or workers to receive the education under the conditions of stable educational opportunity distribution and higher vocational education functions. When $\beta_i > \beta^*$, the student or worker will choose to receive higher vocational education; when $\beta_i > \beta^*$, the student or worker will choose to work in each type of job positions without receiving the higher vocational education. Thus, we can get the relationship between β^* and the enrollment difficulty (the difficulty of receiving the education) F as:

$$\chi(F) log(\mu\beta K_o(\beta^* + \xi)) = \rho \log F \tag{12}$$

As can be seen from the above formula, β^* is determined by the labor force quantity K_o provided by the labor market. Next, in order to determine the allocation of workers in different job positions provided by the labor market, this paper discussed the equilibrium of the labor market, and the equilibrium conditions of the labor market are given by the two formulas below:

$$K_o = \beta^* + \left(1 - p^{-\frac{\varepsilon}{F}}\right)(1 - \beta^*) \tag{13}$$

By multiplying the labor force quantity of professional skill positions by the ability level, we can get the efficient labor force S_o:

$$S_o = p^{-\frac{\varepsilon}{F}}(1 - \beta^*)\left(\frac{1 + \beta^*}{2} + \xi\right) \tag{14}$$

By combining the above two formulas, we can get the relationship of F and β^* as follows:

$$p^{-\frac{\varepsilon}{F}} log\left(\mu\beta\left(\beta^*\left(1 - p^{-\frac{\varepsilon}{F}}\right)(1 - \beta^*)(\beta^* + \xi)\right)\right) = \rho \log F \tag{15}$$

At last, the growth rate of the rewards of higher vocational education is calculated. Based on above analysis, under the condition that the difficulty of receiving education F is stable, then the stability of educational opportunity distribution and higher vocational education functions determines the dividing point of labor force allocation β^*. At this time, the growth rate of the final rewards of higher vocational education B_o is basically consistent with the growth rate of production process upgrading and product

R&D innovation X_o, the following formula calculates the growth rate of the rewards of higher vocational education:

$$h_o = \lambda(\alpha - 1) = \mu S_o(\alpha - 1) = \mu p^{-\frac{\varepsilon}{F}}(1 - \beta^*)\left(\frac{1 + \beta^*}{2} + \xi\right)(\alpha - 1) \tag{16}$$

Through the above analysis, it's known that, the difficulty of receiving education F can affect the population ratios of ordinary high school graduates, secondary vocational graduates, and social candidates receiving higher vocational education, and the ability of professional skill positions to upgrade production process and invest in production R&D, which finally determines the level of the rewards of higher vocational education.

3 The evolution of unfairness in education opportunities and difference analysis

In terms of the setting of the theoretical model, this paper built a higher vocational education selection model which fully considers the factors of the scale expansion of higher vocational education, here, the cost for individuals to receive higher vocational education decreases with the expansion of the scale of higher vocational education. At the same time, this paper distinguished the differences between different levels of higher vocational education in reality, and divided these levels into the junior college level, the college level, and the graduate school level. In addition, there're certain differences in the personal abilities of different students or workers and their attitudes toward higher vocational education. Based on the existing analysis and the constructed model, this paper focuses on analyzing the evolution mechanism of the unfairness degree of students or workers attaining different levels of higher vocational education opportunities during the expansion of the scale of higher vocational education.

At first, this chapter discusses for a student or a worker with a personal ability of β_i and an educational attitude of b_i, how to make choices between different levels of higher vocational education (junior college level, college level, and graduate school level). Assuming φ_1 represents the enrollment difficulty of schools; δ represents the expansion degree of the enrollment of schools; entering the junior college level (higher educational) schools requires students or workers to make personal efforts or pay certain costs, which can be written as $D_{i1}(\varphi_1, \delta, b_i, x_i)$.

Assuming: θ_0 represents the income of students or workers who choose not to receive higher vocational education, the effect of the income is V_1; θ_1 represents the income of students or workers who choose to receive higher vocational education, and the effect of the income is V_2. When $V_1<V_2$, receiving the education is better than not receiving it; when $V_1>V_2$, not receiving the education is better than receiving it. According to $log\theta_0 = log\varphi_1/\beta_i b_i^{\lambda}\delta^x$, we can get:

$$\beta_1^* = \frac{1}{log(\theta_1 / \theta_0)}\phi_1 b_i^{-\lambda}\delta^{-\beta} \tag{17}$$

Then, it's known that, when $\beta_i \geq \beta^*_i$, there is $V_2 - V_1 = log(\theta_1/\theta_0) - D_1(\varphi_1, \delta, b_i, \beta_i) > log(\theta_1/\theta_0) - D_{i1}(\varphi_1, \delta, b_i, \beta^*_i) = 0$, so at this time, students or workers would choose to receive the higher vocational education of the junior college level. When $\beta_i < \beta^*_i$, they can choose not to receive the education. Next, the text analyzes how the attitude towards education affects students or workers to make choices over higher vocational education, then there is:

$$\frac{\partial \beta_1^*}{\partial b_i} = -\frac{\lambda}{log(\theta_1/\theta_0)} \phi_1 b_i^{-\lambda-1} \delta^{-\beta} < 0 \tag{18}$$

By taking the derivative of the expansion factors of higher vocational education, the change trend of the differences in the personal ability level of the higher vocational education of junior college level can be attained:

$$\frac{\partial^2 \beta_1^*}{\partial \delta \partial b_i} = \frac{\lambda \beta}{log(\theta_1/\theta_0)} \phi_1 b_i^{-\lambda-1} \delta^{-\beta-1} > 0 \tag{19}$$

Based on above analysis, it's known that, the scale expansion of higher vocational education will greatly decrease the unfairness for different groups of students or workers to receive higher vocational education of the junior college level.

Next, the text continues to discuss the unfairness in receiving higher vocational education of the college level and the graduate school level and the influence of scale expansion of higher vocational education on the unfairness degree. Assuming: V_3 represents the total utility after receiving high-level higher vocational education; θ_2 represents the income of students or workers who choose to receive high-level higher vocational education. Apparently, when $V_2 > V_3$, receiving the higher vocational education of the junior college level is better than receiving high-level higher vocational education; when $V_3 > V_2$, receiving high-level higher vocational education is better than receiving higher vocational education of the junior college level. According to $V_2 = V_3$, the β^*_2 at this time could be determined:

$$\beta_2^* = \frac{1}{log(\theta_2/\theta_1)} (\phi_2 b_i^{-u} \delta^{-\gamma} - \phi_1 b_i^{-u} \delta^{-\beta}) \tag{20}$$

When the ability of individual $\beta_i \geq \beta^*_2$, there is:

$$V_3 - V_2 = log(\theta_2/\theta_1) - \frac{\phi_2 b_i^{-u} \delta^{-\gamma} - \phi_1 b_i^{-\lambda} \delta^{-\beta}}{\beta_i} > log(\theta_2/\theta_1) - \frac{\phi_2 b_i^{-u} \delta^{-\gamma} - \phi_1 b_i^{-\lambda} \delta^{-\beta}}{\alpha_2^*} = 0 \tag{21}$$

Therefore, at this time, students or workers would choose to receive high-level higher vocational education. When $\beta_i < \beta^*_2$, they could choose to receive the higher vocational education of the junior college level. Similarly, the text also analyzes how

the ability of individual β_2^* of high-level higher vocational education changes with the attitude towards education b_i, then there is:

$$\frac{\partial \beta_2^*}{\partial b_i} = \frac{1}{log(\theta_2 / \theta_1)} (\lambda \phi_1 b_i^{-\lambda} \delta^{-\beta} - u \phi_2 b_i^{-u} \delta^{-\gamma}) b_i^{-1} \tag{22}$$

To figure out how the individual ability difference of different groups receiving high-level higher vocational education changes with the scale expansion of higher vocational education, this paper further takes the derivative of the above formula, then there is:

$$\frac{\partial^2 \beta_2^*}{\partial \delta \partial b_i} = \frac{1}{log(\theta_2 / \theta_1)} \left[\gamma u \phi_2 b_i^{-u} \delta^{-\gamma} - \beta \lambda \phi_1 b_i^{-\lambda} \delta^{-\beta} \right] b_i^{-1} \delta^{-1} \tag{23}$$

Although there is $\varphi_2 b_i^{-u} \delta^{-\gamma} > \varphi_1 b_i^{-\lambda} \delta^{-\beta}$, when the parameters satisfy $u < \lambda$ and $\gamma << \beta$, the above formula may be less than 0. The condition of $\gamma << \beta$ indicates that the scale expansion of higher vocational education of junior college level is far greater than that of the other two levels (the college level and the graduate school level) of higher vocational education, and this is in line with the actual situation. At this time, there is $\partial^2 \beta^*_2 / \partial \delta \partial b_i < 0$.

4 Experimental results and analysis

Figures 1 and 2 give the enrollment number, employment number and ratios of high-level and junior college-level higher vocational education. In China, although the enrollment scale of higher vocational education at different levels shows a rising trend, compared with the two types of high-level higher vocational education at the college level and the graduate school level, the scale of higher vocational education at the junior college level is relatively low.

Figure 3 shows the enrollment of different-type higher vocational education in 2021, including the junior college level, the college level, and the graduate school level; other types include joint school-running forms such as "secondary vocational college + higher vocational college" and "higher vocational college + undergraduate college". As can be known from the figure, in the 50 higher vocational colleges, the increase of enrollment is mainly in engineering related majors, computer and network related majors, and economic management majors. Nearly 70% of higher vocational colleges provide courses to train high-quality skilled talents majoring in engineering, computer and network, and economic management, and some of them can provide training courses in both type of majors. In contrast, there are fewer higher vocational colleges that provide joint school-running forms.

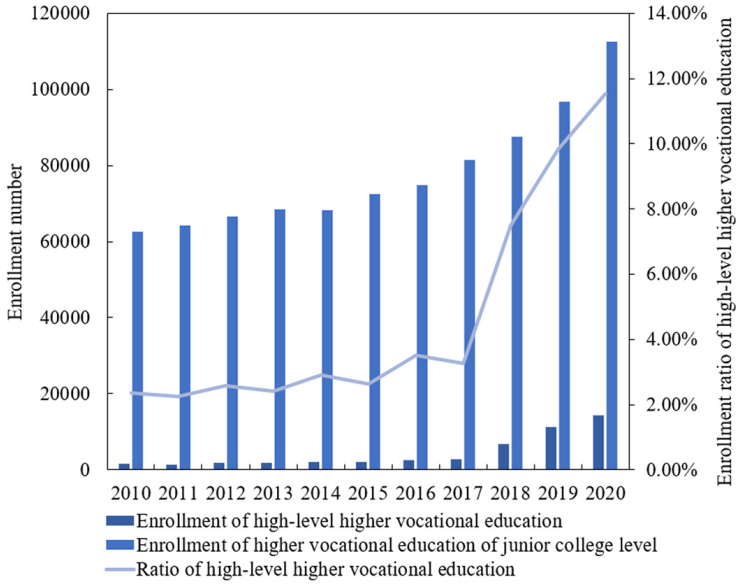

Fig. 1. Enrollment of high-level and junior college-level higher vocational education and ratios

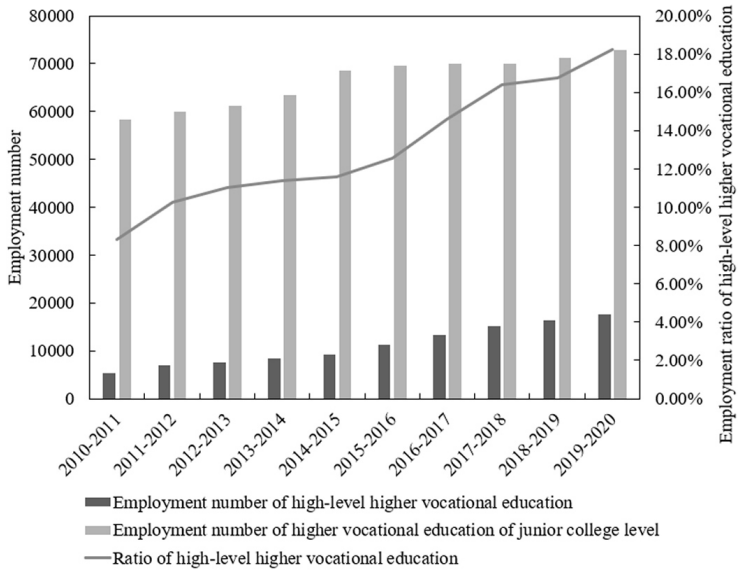

Fig. 2. Employment of high-level and junior college-level higher vocational education and ratios

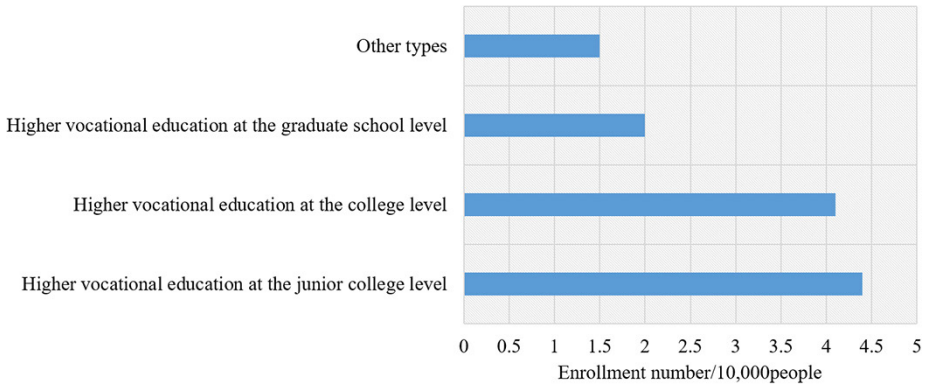

Fig. 3. Enrollment of different-type higher vocational education in 2021

In the paper, the missing data were supplemented based on the interpolation method. Table 1 gives descriptions of statistical variables. Table 2 gives statistics of the Morans'I of the scale expansion of higher vocational education in 2008–2020.

Table 1. Descriptions of statistical variables

Variable	Observed Value	Mean	Standard Deviation	Minimum	Maximum
Degree of college enrollment expansion	3014	612.47	748.06	1.3	5471
College enrollment difficulty	3629	692.35	2843.25	0.05	41528.4
Salary rate	3742	0.5274	0.2417	0.1	8.49
Education rewards	3025	1250.47	3602.59	0.3	5284.72
Ability evaluation	3471	42.69	12.35	5.41	85
Labor quantity	3925	15174.7	15823.7	1623.7	162351
Education participation cost	3051	6.52	6.48	0.352	125
Education facility	3427	9.84	6.02	0.12	132.6
Enrollment scale	3723	125.3	184.37	16.39	1847

Table 2. Statistics of Morans'I of scale expansion of higher vocational education in 2008–2020

Year	*Morans'I*	*Z-Value*	*P-Value*
2008	0.152	6.304	0.001
2009	0.263	7.418	0.003
2010	0.274	7.635	0.008
2011	0.250	7.428	0.001
2012	0.296	7.142	0.002
2013	0.213	7.619	0.004
2014	0.204	7.418	0.008
2015	0.263	8.625	0.001
2016	0.291	7.162	0.006
2017	0.258	7.418	0.004
2018	0.261	7.625	0.002
2019	0.237	7.195	0.003
2020	0.239	7.374	0.006
Mean	0.228	7.528	0.004

According to Table 2, within the research period of 2008–2020, the value range of the Morans'I of the scale expansion of higher vocational education is within [0.152, 0.291], which has passed the significance test of 1% confidence interval, indicating that for the 50 higher vocational colleges participating in the experiment, there're significant spatial interactions between them in terms of enrollment expansion.

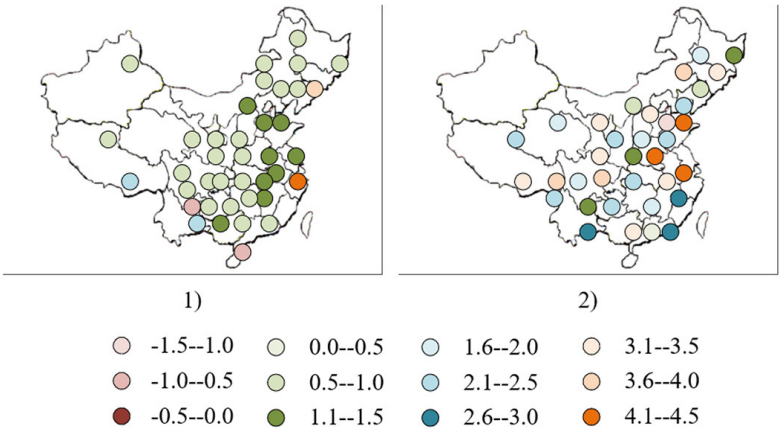

Fig. 4. Spatial distribution of enrollment expansion level in 2008 and 2020

Figure 4 shows the spatial distribution of enrollment expansion level in 2008 and 2020. As can be seen from the figure, there're regional differences in the enrollment of 2008 and 2020, and the scale expanded significantly, wherein the degree of scale expansion of higher vocational education in Jiangsu-Zhejiang and Beijing-Tianjin regions is greater, while the degree of scale expansion of higher vocational education in western regions is lower.

Figure 5 shows the change of education rewards with enrollment scale expansion. As can be known from the figure, the education rewards of students or workers attained from participating in higher vocational education shows a significant increasing trend with the expansion of enrollment scale, and for regions with greater expansion degree, the attained education rewards are higher. However, with the development of regional education, the expansion of regional higher vocational education will inevitably lead to changes in the education rewards of students or workers in the region, but there is no specific research conclusion on the influence mechanism of that yet. Therefore, this paper conducted correlation analysis on the education rewards attained by students or workers who chose to participate in higher vocational education and the enrollment scale expansion within the research regions during the research period, and the results are given in Figure 5. As can be seen from the figure, with the expansion of the enrollment scale, the education rewards attained by students or workers who chose to participate in higher vocational education showed a significant logarithmic growth trend.

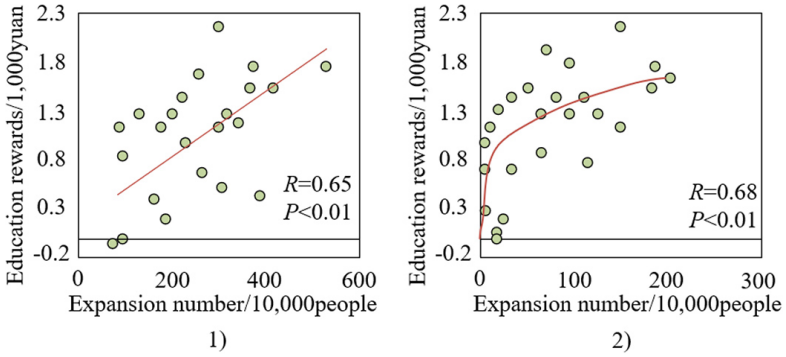

Fig. 5. The change of education rewards with enrollment scale expansion

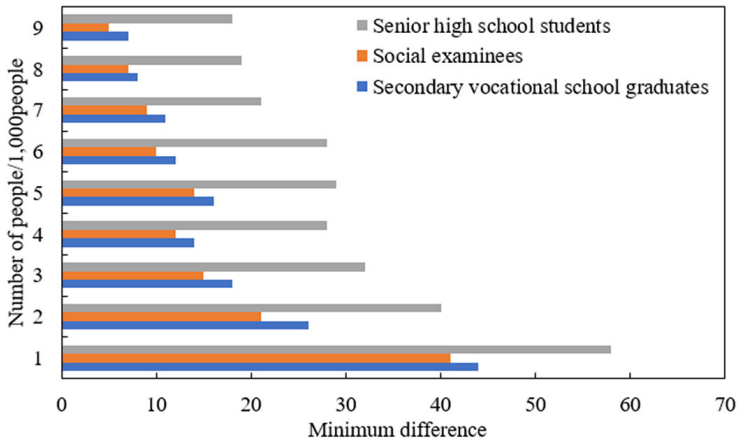

Fig. 6. Comparison of educational opportunity difference between different types of students

Figure 6 compares the difference in educational opportunities between different types of students. On the whole, this paper focuses on the difference in the different types of student sources of the enrollment opportunities of high-quality vocational colleges. Referring to existing research results, it can be found that the superficial phenomenon, namely the difference in enrollment, has gradually become less significant, but it doesn't mean that the difference in the quality of talent training is not ideal. Especially in high-level higher vocational education, for students or workers, the gap in obtaining educational opportunities is expanding gradually. Through the analysis of this paper, it can be concluded that the main reason for the difference in enrollment opportunities of high-level vocational colleges is the difference in the quality of middle school education in urban and rural areas. Therefore, if we want to balance the difference in enrollment opportunities, we should start with narrowing the gap of educational infrastructure and resources between urban and rural areas.

5 Conclusion

Based on the expansion effect, this paper explored the evolution of the scale of higher vocational education in China and measured the difference in educational opportunities. In the beginning, this paper built a theoretical model for describing the scale expansion of higher vocational education and used it to figure out the reward mechanism of the scale expansion of higher vocational education in the labor market. Secondly, this paper distinguished the different levels of higher vocational education in reality, and analyzed the evolution mechanism in the unfairness degree of opportunities for students or workers to attain different-level vocational education during the process of scale expansion. Combining with experiment, the enrollment number, employment

number and ratios of high-level and junior college-level higher vocational education were given, and the enrollment situation of different-type higher vocational education in 2021 was given as well. Moreover, this paper gave the descriptions of a few statistical variables, and the statistics of the Morans'I of the scale expansion of higher vocational education from 2008 to 2020. The experimental results verified that, for the 50 higher vocational colleges participating in the experiment, there're significant spatial interactions between them in terms of the enrollment expansion. At last, this paper gave the spatial distribution of enrollment expansion level in 2008 and 2020, discussed the change of education rewards with enrollment scale expansion, compared the difference in educational opportunities between different types of students, and proposed suggestions for balancing the difference in the enrollment opportunities of high-level higher vocational colleges.

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