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Article

Research on the Calculation and Optimization of the Agglomeration Effect of Specialty Groups in Higher Vocational Colleges in China under the Background of High-quality Development

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Abstract: The key to the construction of high-level specialty groups lies in the generation of agglomeration effect. It shows three effects: scale, sharing and innovation. The analysis of 242 samples based on entropy weight TOPSIS method shows that the innovation effect is more prominent than the three, but the overall agglomeration level of specialty groups is not high, and the category difference is obvious. The optimization of agglomeration effect depends on reinforcement of holistic concept, improvement of mechanisms and establishment of quality assurance system.

Keywords: specialty group; agglomeration effect; higher vocational colleges; China

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1. Introduction

In China, the specialty group is an important part of the "double high plan". As a major project, the plan establishes the overall requirements and main reform and development tasks of higher vocational colleges and specialty groups with Chinese characteristics and world standards. [1] As a systematic design, the "Double High Plan" helps to lead the high-quality development of vocational education, correspondingly specialty groups have become an effective path to deepen the reform of higher vocational education and an important carrier to support industrial transformation and upgrading.

The specialty group is an organic combination of majors or directions within higher vocational colleges with same foundations, similar technologies, and related positions. The construction of high-level specialty groups is conducive to deepening the supply-side reform of technical talents, enhancing the competitiveness of higher vocational colleges, and enhancing the adaptability of vocational education. The core of the construction of specialty groups lies in the generation of agglomeration effect, that is, by changing the partitioned state between majors, promoting cross-border cooperation and knowledge flow, and integrating related elements to form an advantage effect, which is of great significance for solving the contradiction between supply and demand of technical talents, inefficiency of resource sharing among colleges, and low enthusiasm for enterprises to participate in running schools, with the agglomeration effect as the starting point.

The agglomeration effect of specialty groups has the following important characteristics [1]. Integrity, compared with the decentralized influence, the agglomeration effect comes from the comprehensive function of the group as a system, that is, the new advantages due to the integration of talents, knowledge, information, funds and other elements. The convergence of related elements is conducive to breaking through the bottlenecks such as the current resources are too dispersed, the characteristics are difficult to highlight, and the linkage with the industry is insufficient. (2) Expansiveness, high-level colleges and high-level specialties are essentially a symbiotic relationship, and higher vocational colleges in the environment of limited resources and fierce competition must concentrate on strengthening the construction of specialty group with characteristic advantages and choose a cluster development mode. The specialty group is in dynamic development, and the agglomeration effect is reflected in causing linkage phenomenon, expanding radiation range and enhancing influence effect by deriving new specialties within the group or absorbing other specialties outside the group. (3) Self-organization, the emergence of agglomeration effect depends on the internal relationships between specialties due to the cohesion of knowledge attributes, technical foundations, and industry fields, and is not the result of external forced intervention, agglomeration triggers coordination between specialties, and then evolves into a self-strengthening process of path dependence and cumulative causation.

In the process of deepening the reform of higher vocational education, specialty groups still face many challenges, both due to the uncertainty of the external environment and the immaturity of own models. Therefore, taking the agglomeration effect as the key point and an important basis for judging the development stage and level of specialty groups, and then more effectively implementing supervision, forecasting and regulation, it is conducive to promoting the adaptability of talents, carrying out technological innovation and focusing on regional needs and is also conducive to the administrative departments to more comprehensively and scientifically grasp the situation, characteristics and direction of higher vocational education in the region, so as to guide the high-quality development of higher vocational education in a more targeted manner.

2. Literature Review

The research on agglomeration problems in the field of education, on the one hand, draws on the relevant achievements of economics and management, and on the other hand, it has its own particularity, with the purpose of disseminating, creating and using knowledge rather than seeking economic benefits, mainly involving three aspects. The first is the agglomeration between colleges and universities, including explanations such as strategy, essence, efficiency and motivation theories. The second is the relationship between institutions and other clusters, in terms of specialty groups and industrial clusters, the coordination relationship and coupling development of the two are mainly analyzed [2]. The third is the agglomeration within the institutions, although there is no terminology for specialty groups in foreign academia, but the study of interdisciplinary education can still provide important references. Grubb et al. proposed that American community colleges rely on tandem courses and clusters to achieve educational content integration [3]. Chinese study has focused on the following areas.

First, the establishment of specialty groups. The establishment logic of specialty groups is the premise for the agglomeration effect. The most representative view of establishment is based on the position group, industrial chain, core specialty or educational resource [4]. That is, the layout and adjustment of specialty groups should serve the transformation and upgrading of regional economy, the occupational needs of core positions, the development direction of advantageous majors or the optimal allocation of resources of stakeholders, especially the first three have been more recognized. In addition, some scholars have pointed out that the diversification of occupational categories require different models [5]. The current study has summarized the principles and standards for the establishment of specialty groups, but the interrelationship between elements inside and outside the group has yet to be studied.

Second, the evaluation of specialty groups. The measurement of agglomeration effects is an important part of the evaluation of specialty groups. The academic circle has carried out some research, but the specialty group evaluation is still in its infancy. Zeng Xinwen and Yan Meng introduced concepts such as class density, group intensity, and concentration of specialty groups to quantitatively analyze specialty groups [6]. Fang Feeha et al. constructed evaluation indicators from the dimensions of organization system, training program, curriculum system, teaching staff, training base and explicit achievements of specialty group [7]. Zong Cheng evaluates the scientific, adaptability and contribution of specialty groups [8]. In general, the study on specialty groups evaluation is still relatively weak, on the one hand, there is a lack of relevant theoretical analysis; On the other hand, there are few surveys with empirical data.

Third, the construction of professional groups. The exertion of agglomeration effect is the key to the construction of high-level specialty groups. Focusing on the improvement of specialty groups, some focus on overall change, Mou Yanlin proposed that there are problems such as separation of industry and education, specialty convergence, insufficient coordination, and lack of indicators, which should be strengthened from establishing phased methods, innovating construction models, and improving supporting facilities [9]. Some focus on breakthroughs in key areas, Cheng Jun, Wang Yanan, and Zhang Yanping proposed that the solution to the dilemma of specialty group governance lies in the organization going to entity, decision-making emphasizing co-governance, the system embodying flexibility and evaluation achieving integration [10]. Some from a dynamic perspective, Zhang Dongle proposed the path of early specialty structure adjustment, medium-term talent training reform, and late career service. There is already a certain research basis in this field, but further analysis is needed around the optimization of agglomeration effects.

In conclusion, existing research has been usefully explored, but it has yet to be enriched. It is generally recognized that the value and significance of agglomeration in the development of specialty groups are recognized, but the relevant theoretical research is still not deep enough, for example, the research on its evaluation system is still relatively weak. The construction, evaluation and development of specialty groups are analyzed, and there is still a lack of relevant research on agglomeration effects, especially the mechanism, calculation and optimization of this effect.

3. Indicators Design and Data Distribution

On the one hand, the specialty group is committed to changing the separation between majors, and on the other hand, it emphasizes conforming to industrial development to serve economic and social progress. The agglomeration effect of specialty group mainly comes from three aspects: the formation of the group as a whole, the interaction of various elements in the whole, and the role of the whole and the environment. Correspondingly, the agglomeration effect mainly includes three parts: scale, sharing and innovation, which reflect the overall concentration, internal correlation and external adaptability. The evaluation system is composed of a total of 3 dimensions and 18 indicators, the scale, sharing and innovation effects respectively include X1-X6、X7-X12 and X13-X18 to comprehensively evaluate agglomeration effects. In the study, 242 specialty groups were selected as samples. Table 1 is the evaluation index system, and table 2 is the basic information of samples. In terms of student's number, sample mean was 1262, and the group statistics also showed that 85.12% of specialty groups were within 2000 people. There are 17 main categories of the specialty groups. And due to the small number of samples of public security and justice, news and communication, and biology and chemical industry, they are unified as other categories. The categories with a higher proportion are finance and trade, electronics and information, equipment manufacturing and medicine and health.

Table 1. Evaluation Index System of Specialty Groups Agglomeration Effect in Higher Vocational Colleges.

No.	Index
X1	Number of specialties
X2	Number of specialty categories

X3	Number of specialties with or above provincial title in the group
X4	Proportion of double-qualifications teachers in the group
X5	Equipment value per student of campus training base in the group
X6	Number of cooperative enterprises per student in the group
X7	Number of specialty courses shared by the group
X8	Number of internship and training bases shared by the group
X9	Proportion of class hours taught by group part-time teachers
X10	Equipment value per student donated by cooperative enterprises of the group
X11	Proportion of graduates accepted by cooperative enterprises of the group
X12	Specialty related employment rate of group graduates
X13	Number of awards per student of the group
X14	Number of awards for teaching and scientific research per teacher of the group
X15	Number of invention patents per teacher of the group
X16	Number of government-aided scientific research projects at or above the provincial level per teacher of the group
X17	Funds of entrusted research projects per teacher of the group
X18	Number of industry standards set by per teacher of the group

Table 2. Basic sample information.

Basic Situation		No.	Percentage
Number of students enrolled in the group	Less than 1000	107	44.21%
	1001-2000	99	40.91%
	2001-3000	28	11.57%
	More than 3000	8	3.31%
Main categories of the specialty groups	Finance and commerce	56	23.14%
	Electronics and information	41	16.94%
	Equipment manufacturing	38	15.70%
	Medicine and health	20	8.27%
	Civil engineering	16	6.61%
	Culture and art	16	6.61%
	Education and sports	15	6.20%
	Tourism	13	5.37%
	Public administration and services	7	2.90%
	Agriculture, forestry, fishery and animal husbandry	4	1.65%
	Light industry textile	4	1.65%
	Food, medicine and grain	3	1.24%
	Transportation	3	1.24%
	Energy Power and materials	3	1.24%
	Other categories	3	1.24%

4. Data Analysis

The entropy weight TOPSIS method is ranked and evaluated according to the proximity of a limited number of objects to the idealized target, which has the advantage of making full use of the original data and has less distortion of information. This method measures the nearness degree of the sample to the ideal solution by constructing a standardized evaluation matrix, determining the index weight based on entropy weight, and calculating the distance of the positive and negative ideal solution, and the higher the nearness degree, the stronger the agglomeration effect.

4.1. Data Standardization Processing

The data are represented in the form of a matrix, the original data of 242 samples are standardized, and the normalization method is adopted to obtain the following matrix (Figure 1).

$$R=\begin{bmatrix} 0.079 & 0.072 & 0.022 & \cdots & 0.061 & 0.021 & 0.000 \\ 0.095 & 0.072 & 0.006 & \cdots & 0.070 & 0.017 & 0.050 \\ 0.063 & 0.108 & 0.012 & \cdots & 0.078 & 0.005 & 0.042 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0.047 & 0.036 & 0.026 & \cdots & 0.006 & 0.000 & 0.000 \\ 0.063 & 0.072 & 0.062 & \cdots & 0.045 & 0.008 & 0.000 \\ 0.079 & 0.036 & 0.031 & \cdots & 0.019 & 0.001 & 0.000 \end{bmatrix}$$

Figure 1. Normalized Matrix of 242 Standardized Samples.

4.2. Information Entropy and Entropy Weight

The entropy weight method can effectively take into account the degree of variability of indicators. The information entropy and entropy weight of 18 indicators are calculated shown in table 3 and table 4.

Table 3. Information Entropy for 18 Indicators.

index	E1	E2	E3	E4	E5	E6	E7	E8	E9
Information entropy	0.997	0.981	0.849	0.982	0.583	0.861	0.987	0.989	0.944
index	E10	E11	E12	E13	E14	E15	E16	E17	E18
Information entropy	0.193	0.923	0.765	0.932	0.797	0.750	0.898	0.680	0.688

Table 4. Entropy Weights for 18 Indicators.

index	W1	W2	W3	W4	W5	W6	W7	W8	W9
Entropy weight	0.001	0.006	0.047	0.006	0.131	0.044	0.004	0.003	0.017
index	W10	W11	W12	W13	W14	W15	W16	W17	W18
Entropy weight	0.252	0.024	0.074	0.021	0.063	0.078	0.032	0.100	0.097

The entropy weight is used to describe the relative importance of various indicators, and the higher the entropy weight, the greater the importance. Analysis of the entropy weight of 18 indicators found that the top 5 indicators were: W10 (Equipment value per student donated by cooperative enterprises of the group, 0.252), W5 (Equipment value per student of training base in the group, 0.131), and W 17 (Funds of entrusted research projects per teacher of the group, 0.100), W18 (Number of industry standards set by per teacher of the group, 0.097) and W15 (Number of invention patents per teacher of the group, 0.078), which is mainly distributed in the third dimension.

4.3. Degree Positive and Negative Ideal Solution and Nearness Degree

Combined with the data normalization matrix, according to the positive and negative ideal solution formula, the distance between each specialty group and the maximum and minimum values can be determined, where D+, D- and Si represent the positive ideal solution, negative ideal solution and nearness degree. Table 5 shows the nearness degree of the top 10 samples, analyzes the top 50, the last 50 and all the samples, and compares the different main categories.

Table 5. Positive and Negative Ideal Solution and Nearness Degree of the Top 10 Specialty Groups.

Ranking	D+	D-	Si	Ranking	D+	D-	Si
1	0.5601	0.4125	0.4241	6	0.6434	0.2125	0.2482
2	0.5705	0.2885	0.3359	7	0.6385	0.1968	0.2356
3	0.6261	0.3066	0.3287	8	0.6614	0.1465	0.1814
4	0.6118	0.2933	0.3241	9	0.6671	0.1416	0.1751
5	0.6430	0.2650	0.2918	10	0.6603	0.1310	0.1655

Table 5 lists the positive and negative ideal solutions and nearness degree of the top 10 specialty groups, and Figure 2 compares the scores of the three groups of samples, showing the maximum, minimum, and mean values of each one. The comparison found that the mean value of the top 50 specialty groups was 0.1293, significantly higher than the 0.0153 and 0.0525 of the latter two. The lowest score of the top 50 specialty groups was 0.0666, which is also significantly higher than the mean score of the total sample.

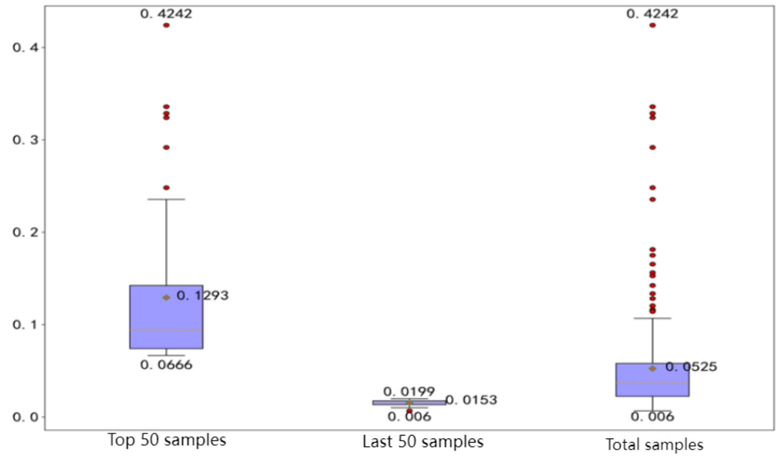

Figure 2. Nearness Degree of the Top 50, the Last 50 and All Specialty Groups.

Table 6 compared the 8 main categories with the largest number of samples of the specialty groups. The four categories with the largest mean value are 0.0684 for culture and art, 0.0662 for equipment manufacturing, and 0.0650 for civil engineering. The largest standard deviation is 0.0766 for civil engineering and 0.0125 for tourism.

Table 6. Nearness Degree of Main Categories of the Specialty Groups.

Category	Count	Mean	Std	Min	Max
Civil engineering	16	0.0650	0.0766	0.0153	0.3241
Equipment manufacturing	38	0.0662	0.0367	0.0137	0.1814
Electronics and information	41	0.0436	0.0519	0.0104	0.3359
Medicine and health	20	0.0446	0.0516	0.0124	0.2482
Finance and commerce	56	0.0420	0.0482	0.0066	0.3287
Tourism	13	0.0282	0.0125	0.0114	0.0467
Cultural and art	16	0.0684	0.0665	0.0175	0.2918
Education and sports	15	0.0323	0.0178	0.0131	0.0723

5. Conclusions

5.1. The Role of Innovation Effect Is Even More Important

An analysis of 242 samples revealed differences in the roles of scale, sharing and innovation effects played in agglomeration. Compared with entropy weight of the three dimensions, the innovation effect was 0.391 higher than the 0.374 of sharing effect and 0.235 of scale effect, indicating that the role of innovation effect was more important. Among the six indicators of innovation effect, the three with the highest scores were funds of entrusted research projects per teacher of the group 0.100, number of industry standards set by per teacher of the group 0.097, and number of invention patents per teacher of the group 0.078. Compared with the rest of the indicators, these items emphasize practice-based, industry-oriented and output results. The sharing effect includes both the sharing of on-campus resources and school-enterprise resources, and the impact of the latter is more obvious. The three highest scores in the six indicators of this dimension are concentrated among schools and enterprises. Among the scale effect, the three with the highest scores were 0.131 for the equipment value per student of campus training base in the group, 0.047 for number of specialties with the provincial title in the group, and 0.044 for number of cooperative enterprises per student in the group. This once again reflects the importance of improving basic conditions in the scale effect, and at the same time shows that scale development is not blindly increasing the number of specialties, but lies in the collection of high-quality specialties and the expansion of external resources such as cooperative enterprises.

5.2. The Level of Agglomeration Effect Needs to Be Improved

Figure 1 compares the top 50, last 50 and the total samples, showing that the mean of the top 50 is significantly higher than the latter two, and the highest score of 0.4242 in the total samples is 64.3 times than that of the lowest score of 0.0066. The 0.0835 of the top 50 in the standard deviation is also significantly higher than the 0.0030 of the last 50 and the 0.0560 of the total samples. Even within the top 50, the score of the first one is 6.4 times than that of the 50th. This shows that the proportion of specialty groups with high scores on the agglomeration effect is small, and the overall level needs to be improved. The indicator values also illustrate this problem. Although some are already at a relatively good level, such as the mean value of proportion of double-qualifications teachers has reached to 79.92%, there is still a lot of room for improvement in some indicators. The number of specialty groups without any provincial titles has reached 124, accounting for 51.24%. Many specialty groups are even blank in some indicators, only 66 (27.27%) of the specialty groups have set industry standards, 136 (56.20%) of the specialty groups have not obtained any invention patents. The specialty groups still need to be strengthened in responding to the needs.

5.3. The Differences Between Categories Are Quite Obvious

Based on the main categories, Table 6 lists the specialty groups with a sample size of more than 15. Mean score of cultural and art, civil engineering and equipment manufacturing are relatively high. In addition, the energy power and materials, transportation and food, medicine and grain are not listed in the table due to the small sample size, but the score is also high. The lower scores are mainly in the tourism and education and sports. The specialty groups with high scores have the following characteristics: Firstly, focusing on the industrial layout, such as material engineering technology, mechatronics technology, marine power engineering technology, etc. are mainly for strategic emerging industries. Industrial robot technology, automobile testing and maintenance technology, etc. are mainly oriented to advanced manufacturing. Environmental art design, product art design, etc. are mainly for the creative industry. Secondly, focusing on regional development, specialty groups with higher scores are often based on regional priority or pillar industries, such as there are many new energy automobile enterprises in the region, and the ranking of related specialty groups is also in the middle and upper reaches of the total samples. The local is one of the centers of traditional Chinese medicine, and the agglomeration effect of traditional Chinese medicine specialty groups is also significantly higher than that of other categories. Thirdly, focusing on characteristic development, for example, the specialty group of intelligent optoelectronic manufacturing technology is composed of optoelectronic manufacturing and application technology, mold design and manufacturing, mechanical manufacturing and automation and mechatronics technology, effectively integrating a series of technologies such as optics, mechanics, electronics and image recognition and artificial intelligence applications. However, groups formed by traditional specialties such as hotel management and school education can only become loosely combination and difficult to play the role of clustering, if they fail to make a breakthrough or form advantages in the key direction and fail to form knowledge cooperation among stakeholders.

6. Recommendations

The agglomeration effect points out an important direction for the construction of specialty groups. Higher vocational colleges rely on specialty development, but in the process of forming a real organism, also face many challenges: the motivation of stakeholders is insufficient, the logic of groups is often ambiguous and lacks a scientific main line, the organizational guarantee has not been tailored for the specialty group, and the quality evaluation has not gotten rid of the traditional judgment standards and methods. Of course, there are also some attempts to break through the above difficulties, such as motivating the participants through the project-based system, strengthening the construction of curriculum sharing platforms, and paying attention to the balance between teachers' theoretical literacy and industry experience. However, without systematic thinking and in-depth change, so-called reform can often be reduced to a mere formality. For example, the course sharing platform needs to redesign the course content, clarify the course relationship and optimize the course structure around the core professional literacy and ability of students, rather than just a platter or stacked mechanical combination. Only by focusing on agglomeration and stimulating the scale, sharing and innovation effects, the specialty group can contribute to the high-quality development of higher vocational colleges. Therefore, taking the agglomeration effect as the starting point, it is necessary to comprehensively consider the multiple influences of colleges, markets and governments, and then reconstruct the interrelationship between specialties, colleges and industries. On the one hand, it is necessary to strengthen the concept of agglomeration in college development, promote the reform with a holistic thinking, enable complementarities within and between specialty groups. On the other hand, it is necessary to pay attention to the continuous improvement of the mechanism, and provide good conditions for all stakeholders to participate in the construction of specialty groups, through a combination of demand articulation, interest harmonization, and incentive and constraint mechanisms. In addition, it is necessary to establish a corresponding quality assurance system, to strengthen the supervision and evaluation, develop a long-term tracking system, and promote the continuous optimization of specialty groups.

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