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Construction and Application of Coupling Coordination Degree Model between Key Specialty Group and Regional Industrial Clusters in Private Colleges and Universities in Hubei Province

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***Abstract*—With the transformation and upgrading of industrial structure in Hubei Province, the professional group of private colleges and universities is playing an increasingly important role. This paper constructs the evaluation index system of key specialty group and regional industrial clusters in private colleges and universities in Hubei Province, and calculates the degree of coupling and coordination between the specialty group and the industry cluster. The results show that the coupling degree between the automobile industry group, the internet operation group, the electromechanical group, the intelligent manufacturing group, the biomedical group and the regional industrial cluster in the private colleges and universities of Hubei Province is in a running-in time, and needs further construction and adaption for the development of industrial clusters.**

Keywords—professional groups; industrial clusters; Coupling Coordination Degree model (CCDM)

I. INTRODUCTION

Circular of the General Office of the State Council pointed up "Relaying Opinion of the Deep Combination between Vocational Education and Regional Industrial" (Guo Ban Fa [2017] No. 95): Promoting the development of education and industry linkage, promoting the construction of disciplines and industries to adapt to industrial transformation and upgrading, and establishing a close-knit industrial chain and innovation chain. The discipline professional system and the development of characteristic professional clusters under the vision of characteristic industries are the overall trend of the development of local higher education institutions in the future. The interaction between regional education and socio-economic systems, synergy and coupling development, the improvement of industrialization level can promote the transformation of education system and the carrying capacity of social economy to education. The education system also promotes industrial transformation and upgrading, and realizes education-society. Increased economic system coupling level [1], as a talent support for local industrial economic development, private colleges and universities can build multi-disciplinary professional groups that are in line with regional industrial structure characteristics and industry enterprise development characteristics, professional mutual support, subject resources sharing, and better coupling with regional industrial clusters through interdisciplinary platforms.

In recent years, few researches have be done on the coupling development of professional groups and regional industrial clusters. Yu Guo (2014) proposed a framework for the coordinated development of key professional groups and key industries in higher vocational colleges in Yangzhou based on the collaborative innovation of school-enterprise, the integration of professional groups and industries, and the optimal allocation of resources. Li Lihong (2014) demonstrated the feasibility of the professional group docking industrial clusters in higher vocational colleges. Zhang Caiyun (2014) proposed that the construction of professional groups should rely on local advantageous industries, pillar industries, high-tech industries and characteristic industries based on the research of higher vocational colleges in northern Anhui Province. Sun Feng (2014) analyzed the synergy mechanism between industrial clusters and professional groups. Wang Zhiwei (2013) proposed the path of local rural vocational education professional group construction based on Jiangsu coastal industrial cluster.

In summary, the current theoretical thinking and framework of the coupling development of professional groups and regional industrial clusters have been basically formed, however, fewer empirical analysis and research have been done on the coupling development goals, elements, and evaluation models focusing on the key professional groups of private universities in Hubei Province. The quantitative analysis of the coupling study with regional industrial clusters is even blank. This paper evaluates the coupling coordination degree between key professional groups and regional industrial clusters in private universities in Hubei Province from the perspective of

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system coordination, and briefly analyzes the influencing factors, and puts forward relevant countermeasures and suggestions for existing problems, in order to reach the goal of industrial transformation and upgrading in Hubei Province, also support the regional economic development in intellectual way.

II. Coordinated Development of Professional Group and Industrial Clusters

A. Professional Group

The professional group refers to the specialized technology or service field, based on the advantages and service objects of the school, according to the same or similar principles of industry and technology, with the school's dominant specialty as the core, and the integration of professional formations formed by relevant professions. These majors have the same theoretical foundation, technical field and professional foundation and share the resources, technology and training projects within the professional clusters.

Coupling Synergy Mechanism between Professional Group and Industrial Cluster

Coupling refers to the phenomenon of interaction and union between two (or more) systems or operational forms through various interactions and effects. This paper borrows the concept of coupling to express the two groups of heterogeneous organizations: private colleges and regional industrial clusters for jointly implement in the industry-university-research cooperation education based on the factors' combination. With the development of the industry life cycle, as well as the professional demand structure changes, the professional group has to adjust its internal professional structure, the talent level, the training level and types, in order to match the industrial structure and meet the developing needs of industry. [2]

III. Construction of Coordination Degree Model Between Professional Group and Industrial Cluster

According to the connotation of coupling degree and coordination degree, construct the coordination level measurement index of professional group and regional industrial cluster, standardize the index data, use the entropy weight method to determine the weight of each indicator [3], and further determine the professional group subsystem (PE) [4] and the level index of the industrial cluster subsystem (EI）.

A. Indicator System Establishment and Data Standardization Processing

1) Establishment of Indicator System

In order to reflect the mutual influence between professional groups and industrial clusters, according to the main economic indicators of innovative industrial clusters and the professional group evaluation indicators proposed by Zhu Li'an and Xia Fangli (2018), 22 relevant indicators were utilized to build the indicator evaluation system(see TABLE I).The industrial cluster indicators include items as follow: the amount of enterprises in the cluster, amount of personnel in the cluster, the number of personnel in colleges and universities, the operating income of the cluster enterprises, the net profit of the cluster enterprises, the total tax paid by the cluster enterprises, the number of authorized invention patents of the cluster enterprises, the number of technology business incubators, and the cluster. Indicators such as the number of R&D institutions and the number of cluster industry alliances. The professional group indicators select the ratio of students to teachers, the number and structure of full-time teachers, the number and structure of part-time teachers, experimental training conditions, teaching funds, industry-university-research cooperation, curriculum resource construction, vocational ability training, management team, quality control, knowledge, competence, employment and social reputation.

2) Data Standardization Processing

Since there are great differences between the specific dimensions and attributes of the subsystem indicators, normalization is required to eliminate the differences between the various dimensions and the attribute differences [5]. Normalize the raw data matrix to $Y=(y_{ij})_{m\times n}$. Its normalization formula is:

$$y_{ij}=\frac{x_{ij}-\min x_{ij}}{\max x_{ij}-\min x_{ij}} \tag{1}$$

3) Define entropy. Entropy of Indicator j is:

$$e_j=-k\sum_{i=1}^{m}p_{ij}\ln p_{ij} \tag{2}$$

among in which, $p_{ij}=\frac{y_{ij}}{\sum_{i=1}^{m}y_{ij}}$ refers to the weight of sample i, under the indicator j, $k=\frac{1}{\ln m}$.

4) Calculation and evaluation of the weight of Indicator j:

$$w_j=\frac{1-e_j}{\sum(1-e_j)} \tag{3}$$

The application of entropy weight method used to define the value and importance of each indicator, and the weights are comprehensively measured (TABLE I.)

TABLE I. Measurement evaluation system and index weights of industrial clusters and professional groups

Coupling system	Indicator code	Indicator system	Weights
Industrial clusters	IE_1	Total number of enterprises in the cluster	0.1456
	IE_2	Total number of cluster personnel	0.1306
	IE_3	Of which: college or above	0.1011
	IE_4	Cluster enterprise operating income	0.0955
	IE_5	Cluster enterprise net profit	0.0920
	IE_6	The total amount of taxes and fees paid by the cluster enterprises	0.1330
	IE_7	The cluster enterprise authorized the invention patent in the same year	0.1127
	IE_8	Of which: technology business incubator	0.0561

Cont. to TABLE I

	IE_9	Number of cluster R&D institutions	0.0865
	IE_{10}	Cluster Industry Alliance Organizations	0.0469
Professional group	PE_1	Student to teacher ratio	0.0403
	PE_2	Number and structure of full-time teachers	0.1190
	PE_3	Number and structure of part-time teachers	0.0410
	PE_4	Experimental training conditions	0.0957
	PE_5	Teaching expenses	0.0620
	PE_6	Industry-University-Research Cooperation	0.0820
	PE_7	Curriculum resource construction	0.1033
	PE_8	Vocational ability training	0.1567
	PE_9	Management team	0.0415
	PE_{10}	QC	0.0785
	PE_{11}	Knowledge ability	0.0717
	PE_{12}	Employment and social reputation	0.1083

B. Establishment of Coupling Coordination Model

1) Calculation of Evaluation Index

The horizontal indicator calculation formulas of the professional group subsystem (PE) and the industrial cluster subsystem (IE) are:

$$PE = \sum_{i=1}^{m} PE_i W_i \tag{4}$$

In the formula, PE refers for the professional group subsystem, PE_i is the standardized value of the indicator i, W_i is the weight value of the indicator i.

$$IE = \sum_{i=1}^{m} IE_i W_i \tag{5}$$

In the formula, IE refers to the industrial cluster subsystem indicator, IE_i is the standardized value of the indicator i, W_i is the weight value of the indicator i.

2) Construction of Coupling Degree and Coordination Degree Model

The degree of coupling means the interaction or the degree of interdependence and correlation. It is a dynamic relationship between the subsystems or internal elements of the system, which are always mutually dependent, interdependent and mutually influential. This paper tries to discriminate the time-series space between the industrial cluster subsystem (IE) and the professional group subsystem (PE). The degree of coordination is the coordination of the various elements within the system and reflects the harmony of the system. The degree of coupling and coordination show us the degree of coordination and development of professional groups and industrial clusters.

Among them, the calculation model of coupling degree and coordination degree is as following:

$$C = \frac{2\sqrt{PE \times IE}}{PE + IE} \tag{6}$$

$$D = \sqrt{C \times T} \tag{7}$$

$$T = \alpha IE + \beta PE \tag{8}$$

There, D is the coupling degree of professional group and industrial cluster; T is the comprehensive integration index of professional group and industrial cluster, which is the development measure of professional group and industrial cluster, C is the coordination degree of professional group and industrial cluster, IE is industry Cluster subsystem index, PE is the professional group subsystem index, α, β are the set parameters, there are 2=1, according to the characteristics of professional groups and industrial clusters and research needs, set α = β = 0.5. Better coordination degree between the professional group and the industrial cluster goes with the increase of C. Higher coupling and development level of the two comes by the increase of D, and vise versa. The specific division criteria of coordination degree and coupling degree are shown in Table II.

TABLE II. COUPLING DEGREE STANDARDS AND COORDINATION STANDARDS FOR PROFESSIONAL GROUPS AND INDUSTRIAL CLUSTERS

Coupling value	Coupling level	Coordination value	Coordination level
D=0	Low level coupling	C=0	Disorder
0.0<D≤0.3	Low level coupling	0.0< C≤0.3	Mild disorder
0.3< D≤0.5	Antagonistic	0.3< C≤0.5	Moderate imbalance
0.5< D≤0.8	Run-in	0.5< C≤0.8	Good coordination
0.8< D <1.0	High level coupling	0.8< C <1.0	Highly coordinated
D=1	Advanced coupling	C =1	Extreme coordination

IV. CALCULATION OF COORDINATION DEGREE OF KEY PROFESSIONAL GROUPS AND INDUSTRIAL CLUSTERS IN PRIVATE UNIVERSITIES IN HUBEI PROVINCE

A. Data Acquisition and Calculation

The data related to industrial clusters in this paper are all from *Hubei Statistical Yearbook*, *Wuhan Statistical Yearbook* and *Donghu High-tech Zone Statistical Yearbook*. The indicators of some private colleges and universities in Hubei Province are obtained through field research and expert scoring. According to the above model and formula, the coupling coordination degree of group of automobile industry chain in colleges, group of automobile industry chain in colleges, group of internet operations in colleges, group of mechanical and electrical in colleges, group of intelligent manufacturing in colleges, group of software in colleges, and group of biology in colleges can be drew as in the following table.

TABLE III. COUPLING COORDINATION DEGREE BETWEEN PROFESSIONAL GROUPS AND INDUSTRIAL CLUSTERS IN TYPICAL PRIVATE COLLEGES AND UNIVERSITIES IN HUBEI PROVINCE

Professional Group	D	Coupling	C	Coordination degree	T
H Group of automobile industry chain in colleges	0.6254	Run-in	0.6532	Good coordination	0.3521
Q Group of internet operations in colleges	0.7094	Run-in	0.8610	Highly coordinated	0.3369
S Group of mechanical and electrical in colleges	0.7290	Run-in	0.7028	Good coordination	0.4236
W Group of intelligent manufacturing in colleges	0.6873	Run-in	0.6533	Good coordination	0.3877
Y Group of software in colleges	0.8851	High level coupling	0.8026	Highly coordinated	0.5166
C Group of biology in colleges	0.5840	Run-in	0.8275	Highly coordinated	0.4970

B. Results and Suggestions

It can be seen from Table III that the coupling degree between the automobile industry chain professional group, the internet operation professional group, the electromechanical professional group, the intelligent manufacturing professional group, the biomedical professional group and the regional industrial cluster in the private colleges and universities of Hubei Province is at a running-in level, which needs further adaption to the development of industrial clusters.

First, the overall specialty provision and enrollment scale of private colleges should be coordinated with economic development. Institutions must work together to reach the goal of scientific division of labor and resource sharing, also avoiding the waste of educational resources. Private colleges and universities can design talent training programs with cluster representative enterprises, to clarify the professional knowledge and professional ability that private graduates should possess. Also they can adjust the courses and teaching structures to build the course system. By the joint training, students would master new abilities as well as new equipment. Focusing on the horizontal expansion and integration of knowledge, they cooperate to plan and build a practical education platform, so that the new training model combined with products development, employee training, school research, internship, employment and teacher training formed in an organically way.

In addition, the specialty provision of private colleges should be combined with the development of industrial clusters to construct a professional group structure system. Due to the different natural endowments and traditional industrial basis, industrial development in various regions requires effective plans and key development. Therefore, it is an effective way to develop the economy by eliminating the aging industry, cultivating emerging industries, and forming an industry cluster with leading industries accompanying related industries. Industrial clusters relies on of the joint investment of capital, technology, talents and information. The industrial clusters have to solve the problems of industrial linkages in order to highlight their advantages. So the structure of talent cultivation needs to be related and matched regardless of the level and category. The professional structure, key professional selection and investment of higher private education in the region need to have a certain proportion and specific structure from the perspective of regional scope. From the perspective of private colleges, it is also necessary to selectively share the training of specific talents in the regional economy. Key majors and related majors must reflect the characteristics of running a school, effectively organize various resources, enter the enterprise, be close to the industry, form their own professional and industry culture, give full play to their professional and technological advantages, and undertake the responsibility of talents training in the industrial division of labor.

Moreover, the specialty provision of private colleges should serve the development of industrial clusters to build a hierarchical system of professional groups. The development of industrial clusters requires continuous technological innovation. To coordinate with the regional economic development, private education must improve the ability serving the industry clusters. Due to the imbalance regional economic development in China, the output of professional talents at the specialist level cannot meet the needs of industrial clusters, thus the education of vocational colleges should also consider the talent demand of regional industrial clusters.

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