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The Development Path of Wenzhou's Integration of the Private Economy and Vocational Education Under the "Four Chain Drive" Model

Abstract: - Wenzhou City, one of the key areas in China for private economic development, has been actively pushing for the deep integration of the private sector and vocational education in recent years, seizing the chance presented by the "Ministry and Province Co-constructing" National Highland of Vocational Education Innovation pilot project. This study attempts to investigate the creative growth path by using the integration of the private business and vocational education in Wenzhou City as the research object and the "four-chain-driven" model as the theoretical foundation. This study determines the research status, issues, and influencing factors of the industry and education integration mode by methodically arranging the academic history and dynamics of related research both domestically and internationally. It also incorporates the chain theory into the relevant research on the evolution of the integration of industry and education, which offers the theoretical foundation for this investigation. Research on the current state of Wenzhou's integration of the private sector and vocational education, research on influencing factors, and research on the "four-chain-driven" model are all included in the study. In order to provide references for governmental decision-making, this study aims to thoroughly analyse the current state of affairs, issues, and potential mechanisms of the integration of the private economy and vocational education in Wenzhou from multiple dimensions through empirical investigation, statistical analysis, and case studies. In the end, this research seeks to create an innovative "four-chain-driven" model of industry-education integration and development that is in line with Wenzhou's real circumstances. It also offers theoretical direction and doable avenues for Wenzhou to achieve superior industry-education integration development.

Keywords:Wenzhou, private economy, vocational education, integrated development, four-chain driven model

I. INTRODUCTION

The relevance of vocational education and the rise of the private economy are becoming increasingly apparent in today's world, and developing and integrating the two is now essential to fostering talent development and long-term economic progress [1]. Vocational education is crucial for developing technical skills, advancing industrial upgrading, and fostering economic transformation, particularly in China where the private sector is playing a bigger and bigger role in the country's economy [2]. Therefore, investigating the integration and development route of the private economy and vocational education, as well as how to realise the beneficial connection between the two sides, is of considerable theoretical and practical value.

With Wenzhou City as a case study and the "four-chain-driven" model serving as the research framework, this paper attempts to investigate the process and mechanism of the integration of the private sector and vocational education. First off, Wenzhou has garnered a lot of attention for its economic dynamism and promise for innovation, making it a prime example of China's private economic development. Wenzhou's integrated development of the private sector and vocational education can serve as a model and source of inspiration for other parts of the nation through in-depth analysis [3].

Second, the "four-chain-driven" model—that is, the natural merging of the talent, education, innovation, and industrial chains—will be the main topic of this study. This concept has the potential to foster close collaboration between the commercial sector and vocational education, as well as to optimise resource allocation, improve economic efficiency, and develop talent. This approach can offer theoretical direction and a useful route for achieving the beneficial relationship between the business sector and vocational education through in-depth study and discussion.

Science Foundation projects are a complex input-output system[8]. From the perspective of investment, the funding intensity of Science Foundation projects has increased significantly in the past ten years, which is limited by the scale of training students (especially doctoral student enrollment) and the time invested in scientific research. Restrictions, the human resource investment of science fund projects may not increase with the increase of funding intensity. As shown in Table 1.

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Table 1 Summary table of funding amounts for business administration disciplines of Wenzhou private economy projects

Particular year	Investment				Produce	
	Amount of subsidy (10000 yuan)	Growth ratio	Scientific researchers (person)	Growth ratio	Number of papers	Thesis citation
2001Year	21.32	-1.62%	6.54	-5.18%	2.28	3.61
2002Year	36.69	25.21%	6.86	3.16%	2.39	11.67
2003Year	26.35	-1.26%	6.91	0.84%	2.55	21.26
2004Year	26.88	1.97%	6.55	-5.24%	2.57	14.71
2005Year	30.53	13.58%	7.22	10.29%	4.74	16.67
2006Year	35.71	16.96%	6.55	-9.18%	7.75	36.85
2007Year	35.38	-0.87%	6.96	6.29%	7.28	36.48
2008Year	37.02	4.61%	6.73	-3.34%	8.31	58.58
2009Year	37.48	1.25%	6.97	3.53%	9.08	53.52
2010Year	40.45	7.91%	7.11	1.67%	9.58	40.86
2011Year	66.22	63.73%	7.14	0.83%	8.31	30.72

From 2001 to 2011, the amount of project funding for the Wenzhou private economy general program business administration discipline has tripled. Except for some years, the funding amount remains basically unchanged, and the funding amount in most years is higher than that of the previous year. A substantial increase, especially in 2011 compared with 2010, the growth rate reached 63.73%.

This paper's strength is found in its first section, which focuses on the multi-dimensional and multi-level integration and development mechanism using the "four-chain-driven" model as the research framework. This can aid in gaining a thorough understanding of the essential components and influencing factors of the integration and development of the private economy and vocational education. Second, using Wenzhou City as a case study, we can examine in great detail the real-world experience of collaboration between local authorities, businesses, and educational institutions. This can serve as a model for the integrated development of other areas. Lastly, in order to support its practical policy recommendations and practical pathways, this paper will draw on empirical investigation, statistical analysis, chain theory, and other relevant theories. It also hopes to positively contribute to the integrated development of the private sector and vocational education.

II. RELATED WORK

Promoting the integration and growth of the private business and vocational education is a crucial responsibility of local governments, since it contributes to the regional economic development. By fusing the features of local industries with the attributes of the colleges themselves, vocational schools and universities throughout the globe have developed a number of creative models for the integration of business and education in recent years. Feels that a successful reform and innovation is the "Digital Jingzhou" industry-education integration model developed by Jingzhou Polytechnic Vocational College in conjunction with Jingzhou's contemporary electronic information industry; believes that the joint construction of the Saudi Qatani College by Liuzhou Vocational and Technical College and the Saudi Qatani Group fully reflects the internationalised development of the economic integration and development of the "One Belt, One Road" economic integration and development; [6] that in order to establish a "school, government, line and enterprise" production and education fusion of a typical model, the Wenzhou Pingyang County Second Vocational School, Shuitou Township Government, Zhejiang Province Import and Export Pet Food Supplies Industry Association, the Great Wall Company, and other six units built the pet industry college.

While there have been numerous successes in the process of developing industry-teaching integration, there have also been many setbacks. According to [8], there are three challenges facing China's higher vocational colleges' ecosystem of talent cultivation for industry-teaching integration: first, a low coupling degree for each system element; second, a poorly functioning process for each system mechanism; and third, a system with insufficient

carrying capacity. Furthermore, there are issues with the integration of the private sector with universities, vocational colleges, and other educational institutions, including challenges in implementing the primary positions of businesses, uniting interests, and strengthening relationships between educational institutions and businesses.

The idea of an industrial chain was initially introduced by Hirschman in his 1958 Economic Development Strategy, which is where chain theory got its start. The multi-chain integration theory has been widely employed in research on the growth of various sectors of society, economics, and education. In recent years, the chain theory has been gradually developed in the process of research on the integration of industrial chain and innovation chain.

Using chain theory to explain how industry and education are integrated, [9] contends that the industrial chain determines the course of contemporary industrial development and that the upgrading and transformation of industries as well as the advancement of teaching reform are significantly impacted by the incorporation of vocational education into the industrial chain. [10] We address the integration of the talent and industry chains based on the service industry chain, and we propose the "dual-chain" education model for the integration of education and industry in the human resource service sector. [11] The framework system of "three chains"—industry, innovation, and talent chains—driven by the merger of higher vocational industry and education is built on the basis of the economic and educational arguments.

The aforementioned research findings show that the integration of the private sector with universities and vocational schools necessitates the integration of a number of components, including platforms for science and innovation, human resources, and policy instruments. The theory of multi-chain integration is vital to this process. There is a dearth of comprehensive study on the "four-chain" driving mode that is ingrained in the integration of industry and education, with the majority of existing research concentrating on single-chain, double-chain, and triple-chain driving modes. In order to investigate the current state of the integration between Wenzhou's private economy and vocational education, this project will look at the four aspects of the "industry chain, education chain, innovation chain, and talent chain" and analyse the issues and factors that influence them. It will also look at excellent practices in typical cases that currently exist and combine them with the successful integration of industry and education that advanced provinces and cities have experienced. Finally, it will methodically present the "four-chain-driven" model of that integration. A methodical proposal is made for the "four-chain-driven" innovation model of industry-education integration development.

III. RESEARCH METHOD

We attempt to construct a "four-chain-driven" industry-education integration model (as illustrated in Figure 1) by utilising the best practices of current typical situations and fusing the successful experiences of the growth of industry-education integration in advanced provinces and cities. First, the "four chains" are broken down into four categories: the talent, education, industrial, and knowledge chains; second, the four key chains are imported into the corresponding flow of talent, technology, knowledge, and information and are continuously recycled to drive the model to form an endogenous development. This is based on an analysis of key factors for the development of the integration of industry and education.

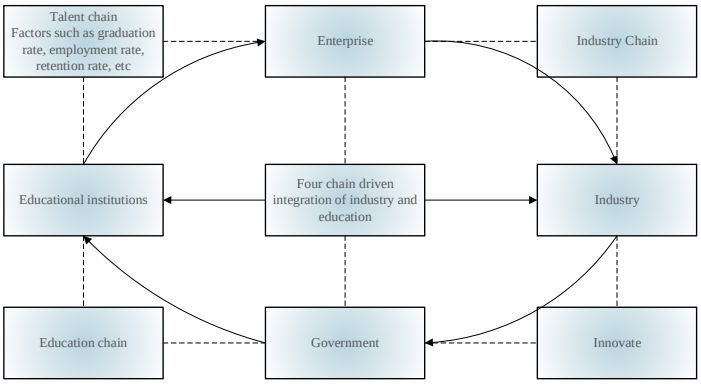

Figure 1 "Four-chain-driven" industry-education integration model

A. Industry chain

An industrial chain is a set of connections and procedures that spans from the procurement of raw materials to the final selling of goods. According to the four-chain-driven model, the integrated development of the private sector and vocational education is led and supported by the industrial chain. First, tight collaboration between private businesses and vocational education facilities is necessary for the establishment of the industrial chain [12]. Vocational education institutions can offer private enterprises technical training and talent support to increase the productivity and competitiveness of enterprises, while private enterprises can provide actual production demand and market feedback to provide a reference basis for training direction and curriculum [13]. Second, the government's backing and direction are essential to the industrial chain's development. By creating industrial policies, offering financial support, and enacting favourable laws, the government may firmly ensure the growth and development of the industrial chain. Finally, innovation and technical advancement must be consistently encouraged as the industry chain develops. It is recommended that private firms and vocational education institutions engage in active collaboration on scientific research, enhance technical innovation and talent training, and provide fresh momentum to the industry chain's sustainable development.

B. Education chain

A network of connections and procedures connecting formal education with career training is referred to as the "education chain." The education chain is a key component of the four-chain-driven model's talent cultivation and skill upgrading strategies. First and foremost, close collaboration between private businesses and vocational education institutions is necessary for a seamless education chain [14]. While vocational education institutions can quickly adjust the training plan and teaching programme in response to business needs and market changes to guarantee that top-notch talent is developed in line with market demand, private enterprises can supply educational institutions with real labour demand and skill requirements, as well as guidance on how to adjust the curriculum and teaching content. Second, government policy support and oversight are necessary for the education chain to run smoothly [15]. By developing educational regulations and bolstering the quality monitoring and assessment of vocational education, the government may encourage the prudent distribution and effective use of educational resources. Finally, broad involvement and support from all facets of society are also necessary for the education system to function well. To collectively support the development of the education chain and provide a favourable atmosphere and conditions for talent cultivation, businesses, educational institutions, governments, and social organisations should improve their communication and cooperation.

C. Innovation chain

The term "innovation chain" describes a network of connections and procedures extending from technological application to scientific research and innovation. The innovation chain is the primary route for achieving industrial upgrading and economic transformation in the four-chain-driven strategy. First and foremost, commercial businesses and academic research organisations must work closely together to build the innovation chain [16]. Scientific research institutions can be strengthened by the support of private enterprises, which can present their actual technical needs and innovation demands, and by the provision of cutting-edge technologies and innovative achievements by scientific research institutions, which in turn can support enterprises' technological upgrading and product innovation. Second, government policy support and direction are necessary for the innovation chain's development [17]. By developing scientific and technology policies, bolstering investment in science and technology, and protecting intellectual property, the government may ensure and encourage the development of the innovation chain. Lastly, talent development and assistance are also necessary for the building of an innovation chain. It is recommended that private enterprises and research institutes enhance their efforts in fostering talent development and introduction, nurture a cohort of researchers possessing inventive awareness and aptitude, and foster the ongoing advancement and expansion of the innovation chain.

D. Talent chain

A talent chain is an arrangement of connections and procedures that go from talent flow to talent nurture. The talent chain plays a crucial role in the four-chain drive model's assurance of the best possible distribution and effective utilisation of talent [18]. First and foremost, strong collaboration between private businesses and institutes of

vocational education is necessary for the talent chain to function smoothly. While vocational education institutions can modify their plans and training programmes for talent cultivation in response to business needs and market fluctuations, private enterprises can supply them with information about the real labour demand and skill requirements as well as guidance and direction for talent cultivation.

E. DEA model of radial returns to scale

In the study of returns to scale, it is inevitable to encounter the phenomenon of blocking. When blocking exists, when calculating returns to scale, first determine whether there is blocking, and then calculate returns to scale. This part of the content determines the blocking according to the WY model, and then calculates the return to scale based on the FDM method without considering the direction. At present, most of the research on blocking is to use the WY-TS model[19]. The WY model is relatively simple in modeling and calculation, and it is widely used. From the perspective of output, a method has been developed. They all believe that blocking is a special state of scale returns , when the input increases, the output will not increase, but will decrease. Based on the BCC, CCR, FG, and ST models, they proposed the WY model, as shown in the following formula.

$$\begin{aligned} &\text{Max} \quad \eta \\ &\text{s.t} \quad \sum_{j=1}^{n} x_{ij}\lambda_j = x_{i0}, i = 1,\dots m \\ &\qquad \sum_{j=1}^{n} y_{rj}\lambda_j \geq \eta y_{r0}, r = 1,\dots s \\ &\qquad \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0,\ j = 1,\dots n, \eta \quad \text{free} \end{aligned} \tag{1}$$

Its basic flow chart is shown in Figure 2.

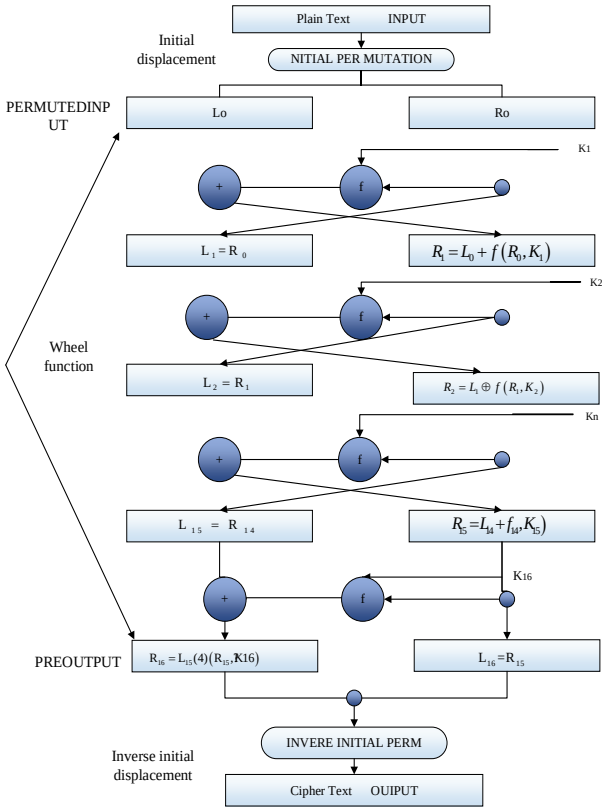

Figure 2 Algorithm flow chart of radial returns to scale DEA model

Regarding the estimation of the algorithm convergence speed, there are mainly the following several formulations The calculation time The probability distribution of the approximate solution converges to the time average

calculation time of the invariant distribution The mathematical expectation of the calculation time is estimated and the average calculation time is obtained by trend analysis[20]. Trend conditions, study average time complexity. Next, first estimate the time for the distribution of the algorithm population to converge to the invariant distribution, that is, the maximum time for the algorithm to converge, and then estimate the time for the population to contain the optimal solution with probability, that is, the time required for the population to contain at least one optimal solution.

F. Determination of the relative best investment direction of NSFA funds

The algorithm is implemented in Matlab7.1 language, and all experiments are carried out on Pentium IV 2.00G, 512M PC. To illustrate the superiority of the algorithm in this paper, the simulation results are compared with the PSO, GA and NM algorithms. The flow chart of the optimal input direction determination is shown in Figure 3.

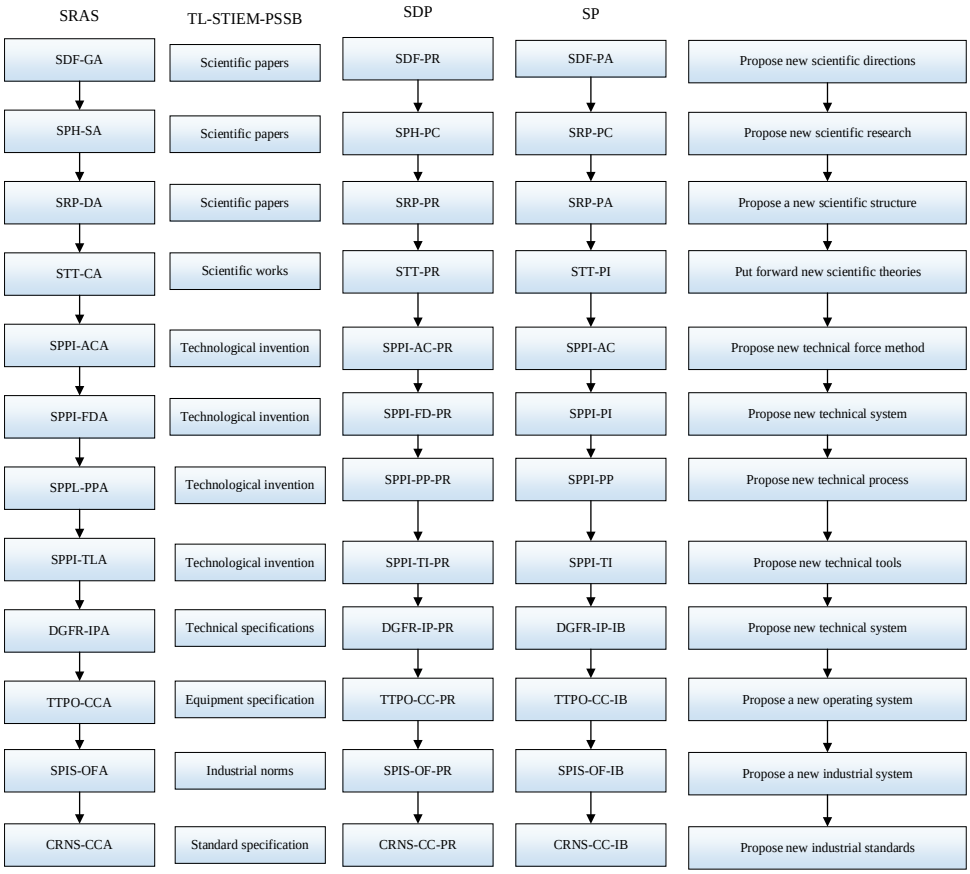

Figure 3 The best decision representation model

Therefore, there is an urgent need for a practical method to optimize the selection of multi-parameter problems in practical applications. The parameter setting problem of SVM also has the same problem, but the realization of the model is slightly different from the form of the parameters.

IV. CASE STUDY

As a scientific research project, the most direct investment in a Science Fund project is project funding (financial), followed by project researchers and participation time. For the experimental conditions and large-scale instruments and equipment required in the project research process, the research must rely on the original site equipment and other large-scale instruments and equipment, not only provided by this project[14]. Therefore, we do not count this part of the investment into a certain Wenzhou private economy. investment in the project. However, in the current research on the efficiency evaluation of science fund projects using the DEA method, the year is often regarded as the decision-making unit, so the input indicators often use the funding amount and the number of funding items. In this paper, to evaluate the scale returns among projects, each project funded by Wenzhou private economy is used

as the decision-making unit, so the funding amount of each project is used as the input indicator. In addition, this paper believes that in addition to the necessary financial expenditure, human resources and time investment are also indispensable for the smooth development of a project[16]. The US National Science Foundation (NSF) also surveyed project leaders and managers. Project personnel and funding deadlines As a necessary investment in the project, the project participants and participation time are also considered as the project investment, and the experimental results obtained are as follows.

A. The Wiener model is highly identifiable

The internal variable k of the Wiener model is not measurable, but its initial value has a great influence on the identification result. In our method, we set the initial value of k to be randomly generated between (-2, 2). In this simulation, we simulated each algorithm 50 times, and then took the average value as the final identification result. As shown in Table 2.

Table 2 Wiener model identification results

Intelligent algorithm	a_1	b_1	m_1	m_2	D	b	R
NM-PSO	0.5000	0.5958	1.0157	1.5227	0.3972	0.2996	88%
PSO	0.4998	0.6294	1.0154	1.5142	0.4089	0.2821	24%
GA	0.4998	0.5961	1.1474	1.7144	0.3912	0.2878	50%
True value	0.5000	0.6000	1.0000	1.5000	0.4000	0.3000	-

From the results in Table 1, we can see that the NM-PSO algorithm is much better than other algorithms in terms of convergence and stability. Figure 4 shows the convergence of each algorithm.

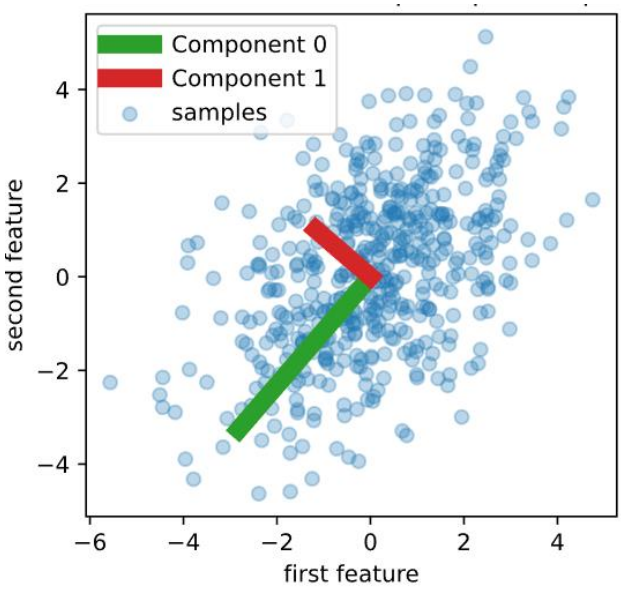

Figure 4 Convergence of different algorithms

From Figure 4, the experimental results clearly show that the optimized nm-pso algorithm has higher convergence than other algorithms in the analysis and layout of fund data.

B. Significantly improved data accuracy

A project produces more papers, and usually the project has a relatively high probability of high quality. Secondly, the quality of papers is usually reflected by indicators such as journal impact factor and citation count. The journal impact factor reflects the evaluation of the quality of the journal, and has no direct relationship with the quality of

a certain paper. The number of citations of a paper as an indicator of the quality of a paper has been recognized by the academic community. Therefore, the number of papers and paper citations usually reflect the characteristics of papers in terms of quantity and quality. According to the data provided by the Wenzhou city in 2011 for the three disciplines A, B and C general projects and youth projects, discipline A is the discipline of business administration. Search and filter input-output indicators. The number of projects provided by the Fund Committee is shown in Table 3.

Table 3 Statistics of the number of projects

Project	General items	Youth Project	Subtotal
Discipline A	373	365	738
Discipline B	443	569	1012
Discipline C	227	183	410
Subtotal	1043	1117	2160

When the emphasis is placed on quantitative output, the blocking rate of the C subject in all directions is relatively high among the three disciplines. As shown in Figure 5.

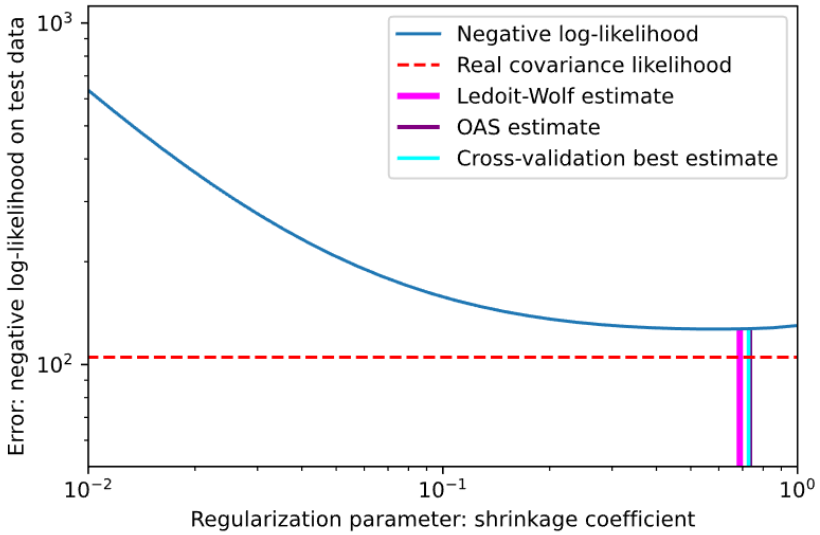

Figure 5 Blocking rates of different disciplines

In the relative optimal investment direction, the optimal scale ratio reaches 11.64% and 6.18%. In the relative optimal investment direction, the blocking rate of the number of papers in the B discipline is lower than the citation output of the papers, indicating that the performance of the number of papers is better than that of the papers Citing performance. As shown in Figure 6.

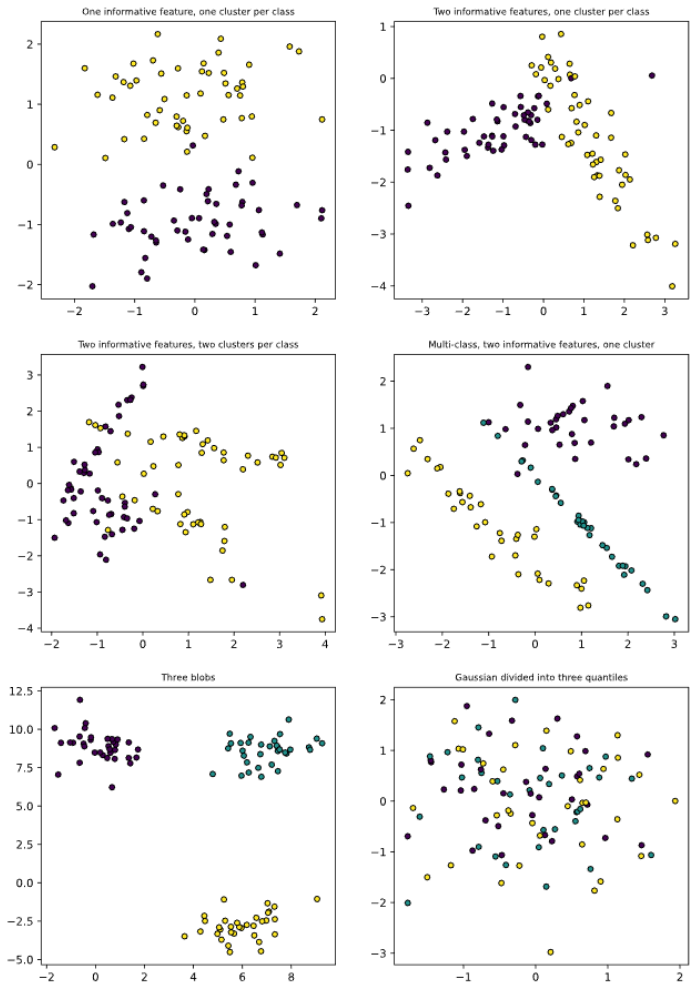

Figure 6 Clustering diagram of relative optimal investment direction

V. CONCLUSION

This study examines the research importance and practical utility of the "four-chain-driven" model in the context of Wenzhou's integrated growth path pertaining to vocational education and the private sector. By means of comprehensive discourse and examination, it is possible to generate novel concepts and approaches for the advancement of the industrial network in Wenzhou, foster the robust growth of the industrial network and augment its overall competitiveness, and actualize the development of the economy in a high-quality and sustainable manner.

The industrial chain is crucial for stimulating economic growth, increasing the employment rate, and fostering industrial upgrading because it is one of the main connectors between the private economy and vocational education. To create a closed-loop industrial chain model, achieve the best resource allocation, and extend the value chain, close collaboration and synergy across all links are necessary during the industrial chain development process.

The introduction of pertinent policies and measures by the government is necessary to provide policy support and guarantee for the development of the industry chain. Government support is a crucial guarantee for the industry chain's development. Industrial policies, financial assistance, tax breaks, and other forms of government support are examples of how to effectively encourage the industry chain's healthy development and raise overall competitiveness.

The advancement of an industrial chain requires constant innovation and improvement. It also requires a constant raising of production efficiency and technology levels, a constant cutting of production costs, and an improvement in product quality and market competitiveness. In order to support the sustainable and healthy development of the

industrial chain, it is imperative that cutting-edge technology and managerial expertise be continuously introduced, as well as that new development modes and pathways be continuously explored and tried.

The trend of future development is multi-chain integration, which calls for the realisation of synergistic and integrated development in a number of areas, including the talent, education, and innovation chains. Multi-chain integration is the trend of future industrial development. We can only achieve the industry's complete improvement and rapid development—as well as contribute to the economy's sustainable growth and the peaceful advancement of society—through multi-chain integration.

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