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Coupling Analysis of Industrial Structure Evolution and Economic Growth in Vocational Colleges Based on Big Data

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Abstract: In key areas of medium economic development, higher vocational colleges and universities need to adjust their specializations in accordance with the industrial structure, thereby promoting the modernization of education and economic growth. Taking City A as an example, this study analyzes the coupling relationship between the professional settings of vocational colleges and the evolution of industrial structure. By analyzing the data on economic transformation, industrial structure adjustment and professional settings of higher vocational colleges in City A from 2015 to 2022, the entropy method is used to determine the weights of indicators and the coupling and coordination models are applied for assessment. The results of the study show that the coupling degree between the professional structure of vocational colleges and the economic and industrial structure of City A has increased from 0.35 to 0.49, reflecting a gradual improvement in the degree of matching between the professional settings and the industrial demands. Meanwhile, the degree of coordination increases from 0.40 to 0.54, showing that the degree of coordination between the professional settings of vocational colleges and the industrial structure has improved. This process indicates that the professional settings of higher vocational colleges and universities in City A are adapting more effectively to the changes in the economic and industrial structure, and that vocational education plays a positive role in supporting the transformation of the regional economy and the optimization of the industrial structure.

1. Introduction

The Guidance Committee for the Construction of Vocational Education Majors is composed of government departments, industry associations, enterprises, and vocational colleges, jointly conducting research, guidance, and services on professional settings and talent cultivation. The education department should be strengthened the main role of enterprises, carry out diversified school enterprise cooperation and industry education integration, accurately and timely convey the latest needs of industries and enterprises to vocational colleges, and form an optimization mechanism that guides the transformation and improvement of professional settings based on demand. Relevant personnel should give full play to the bridging role of industry associations, establish an information exchange mechanism between enterprises, universities, and governments, and use industry associations as a platform to promote leading enterprises in the industry to drive small and medium-sized enterprises to participate in talent cultivation together.

The paper begins with an introductory section reviewing the necessity of aligning vocational education with economic and industrial development planning, especially its strategic significance in key development regions such as northwestern China. Then, the related work section synthesizes previous research results and methods in the field of coupled analysis of economic growth and industrial structure. The method section introduces the application of analytical tools such as entropy value method, coupling degree and coordination degree model and gray correlation degree. Then, the results and discussion section shows in detail the economic and industrial structure data of City A, the professional settings of higher vocational colleges and universities, and the related coupling degree and coordination degree measurement results during the period from 2015 to 2022. Finally, the research findings are summarized and the role of vocational education in regional economic transformation and industrial structure optimization and future research directions are proposed.

2. Related Works

There are many economists who have provided research approaches to analyze the coupling and association between different variables and economic growth, and Wu C used 30 provinces and cities in China as samples to innovatively explore the intrinsic connections between digital finance, green finance, and ecological governance, and for the first time incorporated the three into the same research framework [1]. Wu X analyzed the Sustainable Development Goals (SDGs) interactions for 166 countries using the correlation network approach and a global database, and found that as the SDG index increases, the interactions changed in a non-linear fashion: there were more positive and negative linkages for low and high level countries, and fewer positive linkages for medium level countries [2]. Khalfaoui R explored the relationship between carbon dioxide emissions and economic growth in G7 countries through wavelet coherence analysis. The results showed that carbon dioxide emissions and GDP per capita (gross domestic product) had a cyclical relationship over the business cycle, and there was a bidirectional causal relationship between the two on the time scale [3]. Hou C explored the coupled coordination relationship among economic, ecological environment, and health systems in China from 2009 to 2016 through principal component analysis and entropy value method, and found that health was the key factor, and the degree of coupled coordination showed an M-shape change, which declined after 2012 [4]. Iorember P T analyzed the decoupling of carbon emissions and economic growth in the BRICS countries from 1990-2019, using the C-S ARDL (Cross-Sectionally Augmented Auto-regressive Distributive Lag) method and the Tapio decoupling index, and found that the inverted U-shape curve was consistent with the environmental Kuznets curve hypothesis [5].

Dai J established the ecological carrying capacity index under the pressure-state-response framework to analyze the coupled coordination of ecological pressure, state and response in Chinese cities from 2011 to 2020. The results showed that the degree of coordination of ecological development and the safety index of ecological carrying capacity in Nanchang City improved year by year, but the ecological safety index was still lower than 0.6, which was far from the high safety level [6]. Ganda F systematically analyzed the interaction of financial development and natural resource leasing on carbon emissions in emerging economies. He utilised both generalised least squares with panel data and panel modified standard deviation to conduct the study [7]. Arslan H M analyzed the dynamic relationship between natural resource rents, environmental sustainability and economic growth in China from 1970-2016. The results showed that natural resource utilization improved environmental sustainability but may come at the expense of economic growth [8]. Karaduman C studied 11 emerging industrial economies to examine the impact of factors such as the degree of economic globalisation, the level of human capital, and the level of total capital formation on their ecological footprints using an improved mean-cluster estimation method [9].

Raihan A analyzed the factors of carbon dioxide (CO_2) emissions in Singapore from 1990 to 2020 using dynamic ordinary least squares. The results showed that for every 1% increased in tourism activity, CO_2 emissions increased by 0.50%; for every 1% increase in economic growth [10]. Iqbal A analysed the data on carbon emissions, renewable energy consumption, FDI (foreign direct investment) and exports for the period 2000-2018 [11]. Adeosun O T explored the impact of SMEs entrepreneurship on economic growth in Nigeria over the period 1990-2016. The result showed that the increase in the number of SMEs contributed to economic growth, but the contribution of micro and medium enterprises was small [12]. Kirikkaleli D studied the impact of financial development and renewable energy consumption on consumption-based CO_2 emissions in Chile [13]. Makridis C A studied and analyzed data from 343 cities and found that cities with faster AI job growth also had faster economic growth. The positive correlation between AI job growth and economic growth explains how AI job growth can enhance well-being [14]. The bottlenecks faced by existing studies in coupled correlation analysis mainly include: the first is the lack of in-depth exploration of complex interaction effects, with many studies only focusing on single variables or simple linear relationships; the second limitation is the limitations of data and methods, such as sample selection and model applicability issues, which may lead to biased results; thirdly, the specific background differences of different countries or regions have not been fully considered, which limits the universality and practical application of research conclusions.

3. Methods

3.1. Research Ideas and Methods

(1) Entropy value method

The weight distribution method is a commonly used analytical method for evaluation indicators. The weight allocation method is mainly divided into two categories: one is subjective evaluation method, such as hierarchical analysis method; the second is objective evaluation method, such as entropy value method, standard deviation method, etc [15]. Since each method focuses on different aspects and there is a certain degree of variability between the measurement results, choosing the appropriate method is the key to correctly evaluating the level of high-quality economic development.

(2) Comprehensive development index

Calculating the integrated development index H of the industrial structure and economic growth of vocational colleges and universities, respectively:

$$H = \sum_{j=1}^{m} W_j x_{ij} \tag{1}$$

W_j refers to the weights and x_{ij} refers to the individual economic indicators.

(3) Coupling degree and coupling coordination degree

Calculating the coupling degree between the evolution of industrial structure and economic growth of vocational colleges and universities respectively T.

$$T = 2\frac{\sqrt{H_1 H_2}}{H_1 + H_2} \tag{2}$$

Where H_1 is the industrial structure evolution index and H_2 is the economic growth index.

Calculate the coupling coordination degree of industrial structure evolution and economic growth respectively G.

$$G = \sqrt{T(\alpha H_1 + \beta H_2)} \tag{3}$$

Where α and β refer to the degree of importance of the study system, and α and β take the value of 0.5 in this paper.

3.2. Gray Correlation

The gray correlation model can quantitatively calculate the mutual influence relationship between different indicator variables in the two systems of industrial structure evolution and economic growth, which has more accurate and scientific advantages in the dynamic process analysis compared with regression analysis [16-17]. First, the absolute value of the difference between the evaluated indicator and the reference indicator is calculated $\Delta_{ij}(t)$:

$$\Delta_{ij}(t) = \left|X_{ji}(t) - X_{ij}(t)\right| \tag{4}$$

Second, the coefficient of correlation between the evolution of industrial structure and economic growth is calculated r_{ij}.

$$r_{ij} = \frac{\min\min|\Delta_{ij}(t)| + \rho\max\max|\Delta_{ij}(t)|}{|\Delta_{ij}(t)| + \rho\max\max|\Delta_{ij}(t)|} \tag{5}$$

Where ρ is the discrimination coefficient, which usually takes the value of 0.5.

Finally, the correlation matrix between industrial structure evolution and economic growth is calculated $R_{ij}(t)$:

$$R_{ij}(t) = \frac{1}{t}\sum r_{ij}(t) \tag{6}$$

The larger the value of $R_{ij}(t)$, the stronger the correlation between industrial structure evolution and economic growth. The average correlation between the two systems can be obtained by taking the mean of the correlation between each indicator [18].

3.3. Measurement of Coupling Coordination

Table 1: Criteria for classifying types of coupled coordination

Coordination Type	Coupling Coordination Degree (G)
Complete Coordination	G = 1
High Coordination	$0.8 < G < 1$
Moderate Coordination	$0.5 < G \leq 0.8$
Barely Coordinated	$0.3 < G \leq 0.5$
Nearly Disordered	$0 < G \leq 0.3$
Completely Disordered	G = 0

Since the index evaluation involves x secondary indicators of the “industry-specialty” system with different scales and types, it is necessary to perform dimensionless (indexing) and homothetic processing on the index data before index evaluation. Through the data homogenization process, the values of the indicators are unified into the higher and better type, i.e., the higher the indicator of professional structure of higher vocational colleges and universities, the more reasonable the setting of professional structure; the higher the indicator of industrial structure, the more significant the upgrading of industrial structure. After dimensionless processing, the indicators of forward type and reverse type in this paper are changed into cost type indicators located in the interval of 0 to 1. The criteria for dividing the type of coupling coordination are shown in Table 1.

4. Results and Discussion

4.1. Data Sources

There are 2 public higher vocational institutions in City A: City Vocational College Office and City Joint Vocational and Technical College Office. There are also 3 private higher vocational colleges: Yun Science and Technology Vocational College, Vocational and Technical College, and Information Vocational and Technical College. From September 2022 to February 2023, by visiting the Development and Reform Commission of City A and five higher vocational colleges and universities in City A, we obtained data on economic transformation and upgrading and industrial structure adjustment in City A for a total of eight years from 2015 to 2022, as well as data on the professional settings of higher vocational colleges and universities in City A and the enrollment and employment of each major. Among them, the economic development data come from the statistical yearbook of City A. The data on professional settings and enrollment and employment are provided by the Academic Affairs Offices of the higher vocational colleges and universities in City A.

4.2. Economic and Industrial Structure Data

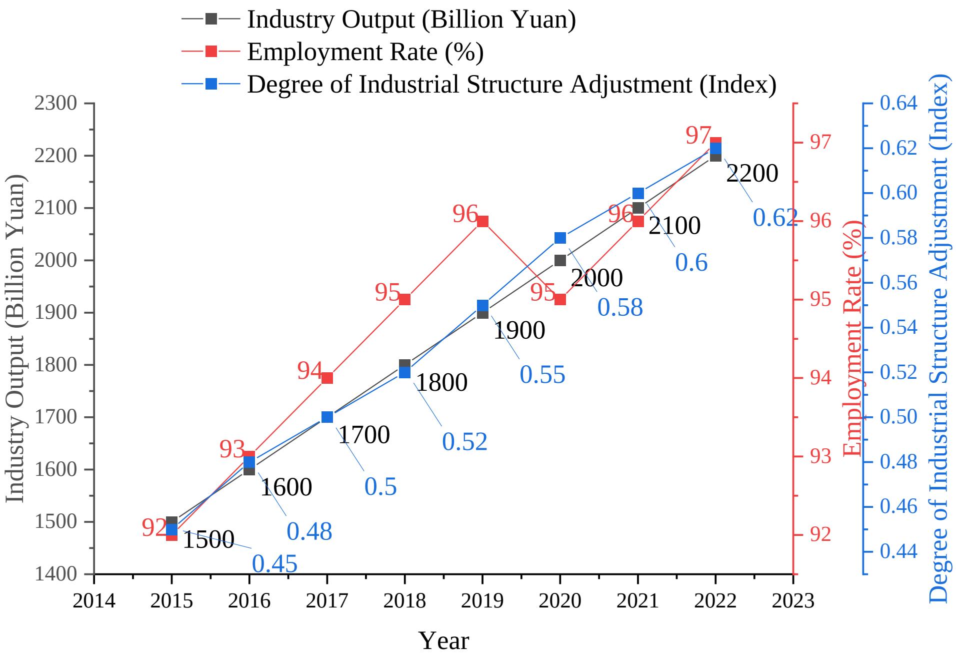

Figure 1: Data on the industrial structure of the economy (2015-2022)

The data analysis covers the changes in the economic and industrial structure of City A as well as the professional settings and enrollment and employment of higher vocational colleges and universities between 2015 and 2022. First, data on the industry structure of City A's economy shows that industry output has steadily increased over the analysis period, from 150 billion yuan in 2015 to 220 billion yuan in 2022. At the same time, employment has increased, reaching 97% in 2022. The index of the degree of industrial structure adjustment has risen from 0.45 to 0.62, which indicates that City A has made significant progress in adjusting and optimizing its industrial structure. This change reflects the results of economic transformation and upgrading in City A. The industrial structure is gradually adjusted in the direction of high-quality development, as shown in Figure 1.

4.3. Specialization of Vocational Colleges and Universities

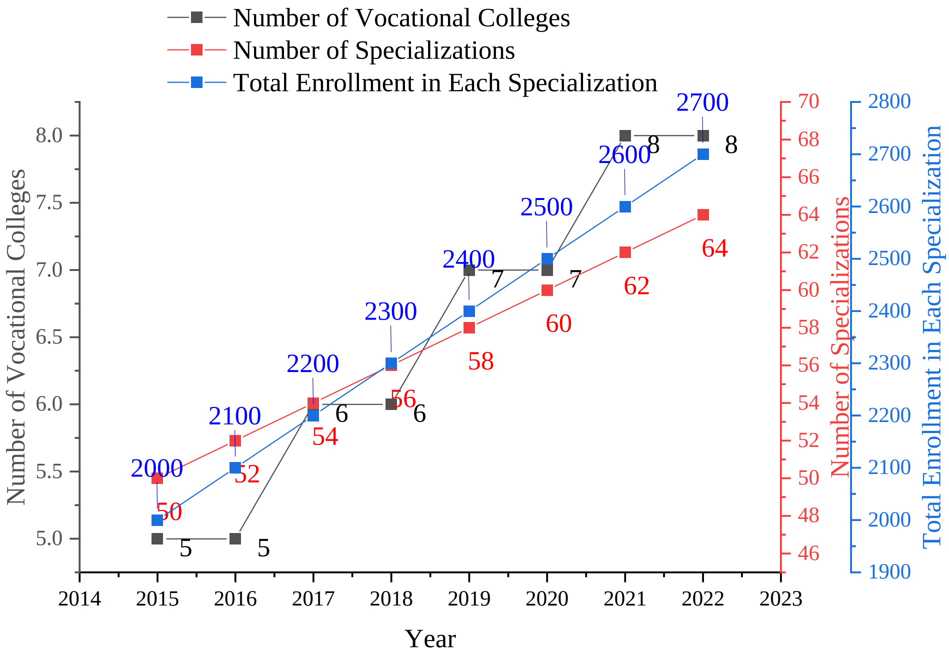

Figure 2: Professional setting data of vocational colleges (2015-2022)

In terms of professional settings in vocational colleges, data shows that the number of vocational colleges in City A has increased from 5 in 2015 to 8 in 2022, and the number of professional settings has also increased from 50 to 64. The total number of enrollments has increased from 2000 to 2700. These data indicate that A city's investment in vocational education has been increasing year by year, and the professional settings of vocational colleges have gradually become more diverse to meet the needs of economic and industrial development, as shown in Figure 2.

4.4. Enrollment Situation of Each Major

Table 2: Enrollment data for each major (2015-2022)

Year	Computer Application Technology	E-commerce	Accounting	Marketing	Mechanical Design and Manufacturing
2015	400	450	500	350	300
2016	420	460	510	360	320
2017	430	470	520	370	330
2018	440	480	530	380	340
2019	450	490	540	390	350
2020	460	500	550	400	360
2021	470	510	560	410	370
2022	480	520	570	420	380

Specific to enrollment and employment by major, five majors - Computer Application Technology, E-Commerce, Accounting, Marketing, and Mechanical Design and Manufacturing -

showed positive changes in both enrollment and employment data. For example, the enrollment of the Computer Application Technology program has increased from 400 to 480 students, and the number of employed students has increased from 350 to 420, which indicates that the program is more responsive to market demand as well as more effective in training. Enrollment and employment figures for e-commerce majors also show strong market demand. The enrollment and employment data for the accounting program, the marketing program, and the mechanical design and manufacturing program all indicate that vocational education in these fields is constantly adapting to changes in industry demand and achieving better results, as shown in Table 2.

4.5. Employment in Different Professions

Table 3: Employment data by specialization (2015-2022)

Year	Computer Application Technology	E-commerce	Accounting	Marketing	Mechanical Design and Manufacturing
2015	350	400	450	300	250
2016	360	410	460	310	260
2017	370	420	470	320	270
2018	380	430	480	330	280
2019	390	440	490	340	290
2020	400	450	500	350	300
2021	410	460	510	360	310
2022	420	470	520	370	320

Employment figures for all programs show steady growth from 2015 to 2022. Employment in Computer Applications Technology grew from 350 in 2015 to 420 in 2022, an increase of 70. The E-Commerce program grew from 400 to 470, an increase of 70. The accounting program increased by 70 students from 450 to 520. The Marketing program increased by 70 students from 300 to 370. The Mechanical Design and Manufacturing program increased by 70 students from 250 to 320. These data show that the job market demand for each specialty is increasing, and the annual growth in the number of jobs in each specialty is roughly the same, reflecting the smooth development of the overall economy and industry, as shown in Table 3.

4.6. Measurement of Coupling Coordination Degree

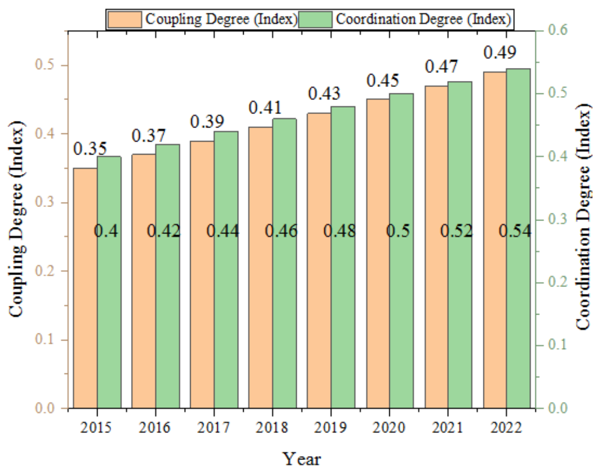

Figure 3: Coupling harmonization measure results (2015-2022)

These data indicate that the professional structure of higher vocational colleges and universities is adapting more effectively to the changes in economic and industrial structure, and the coupling relationship and degree of coordination between the two have been significantly improved, as shown in Figure 3.

5. Conclusion

An in-depth study of the coupling relationship between higher vocational colleges and industry development will not only help rationalize the distribution of higher vocational colleges and universities in various regions of China and cultivate much-needed skilled talents for local economic and social development, but also help promote the upgrading of the industrial structure of various regions. This study reveals the coupling relationship and the degree of coordination between vocational education major settings and regional industrial structure by analyzing the data on the economic and industrial structure of City A and the major settings of higher vocational colleges from 2015 to 2022. The research results show that the coupling degree has risen from 0.35 to 0.49, which shows that the adaptability of vocational education to the industrial demand is increasing. Meanwhile, the degree of coordination rises from 0.40 to 0.54, indicating that the degree of coordination between the professional setting and industrial structure has been significantly improved. This change reflects the effectiveness of vocational education in supporting economic transformation and promoting industrial structure optimization. The results of the study show that by adjusting and expanding their specialization, higher vocational institutions are able to better respond to the needs of the economy and industries and promote the healthy development of the regional economy. In the future, further research could delve into the specific impact of vocational education on economic and industrial restructuring in different regions and industries, in order to optimize the configuration of vocational education and policy formulation.

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