

A Markov Chain Model-based Study of the Impact of College Career Planning Courses on Graduates' Career Paths

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Abstract: Improving the employment quality of college graduates requires a clear understanding of their spatial distribution and influencing factors. This article takes Jiangsu Province, China, as its research object and explores the impact of career planning courses on the employment paths of college graduates. A graduate employment quality evaluation system was constructed, and the entropy method was used to assign weights to the indicators. The Dagum Gini coefficient, kernel density estimation, and Markov chain model were comprehensively used to explore the spatial differences, distribution dynamics, and influencing factors of the employment quality of college graduates in Jiangsu Province. The results indicate that the overall differences in the employment quality of college graduates in Jiangsu Province are narrowing, with regional differences being the primary cause of these differences. Additionally, the overall employment quality of graduates is accompanied by polarization. In terms of spatial distribution patterns, the overall distribution shows a “high in the east and west, low in the central and southern regions” trend, with the spatial pattern shifting from a “east-west” distribution to a “southeast-northwest” direction. In terms of distribution dynamics, there is a stable club convergence phenomenon in the employment quality of college graduates, and there is a “spatial spillover” effect in its development process.

Keywords: Markov chain model; entropy method; kernel density estimation; Dagum Gini coefficient; graduate employment path

1. Introduction

Talent is the primary resource. Implementing an employment-first strategy, strengthening employment-first policies, and improving employment promotion mechanisms to achieve high-quality and full employment are manifestations of national strategy [1-2]. However, with the deepening adjustment of population structure and economic structure, significant changes have emerged on both the supply and demand sides of the labor market. Industrial upgrading and technological progress have imposed higher demands on the skills and qualities of workers, exacerbating the mismatch between talent cultivation and market needs. The coexistence of “employment difficulties” and “recruitment difficulties” has made structural employment contradictions more prominent, becoming the primary contradiction in the employment sector [3-6]. The employment of college graduates and other young people is closely related to people's livelihood, economic development, and the future of the nation. They are a valuable talent resource and therefore an important group for promoting employment [7-8]. In recent years, there has been an issue where graduates lose their direction in job hunting and lack exploration and understanding of industries, organizations, and positions, leading to difficulties in finding employment upon graduation [9-10]. Helping college students gain an early understanding of occupational and position requirements and enhance their employment capabilities aligned with job requirements is of great significance.

Career planning refers to the process by which individuals analyze the subjective and objective factors influencing career choices based on their interests and characteristics, set personal goals, and strive to achieve them [11]. Students who receive proper career planning education and guidance gain a



clear understanding of their thinking habits, personality traits, and knowledge reserves through course selection, participation in school activities, and other opportunities during their academic years. This enables them to develop a long-term career development plan aligned with their career goals [12-15].

Currently, in research on career planning, there has been a significant focus on exploring the pathways through which career planning influences university students' employment outcomes. Zhang, Y. investigated the impact of information technology-enabled career planning education on employment strategies, proposing a planning model based on deep learning that can effectively enhance university students' career awareness and employment capabilities, thereby better assisting them in developing employment strategies [16]. Mikacic, M. T. evaluated career planning education for college students under the current educational model using neurolinguistic programs and tools, indicating that career planning is the cornerstone for university graduates to achieve personal growth and an important force in promoting outstanding career performance [17]. Stipanovic, N. et al. demonstrated that targeted career path planning and career counseling services can enhance college graduates' career and academic efficacy by stimulating their motivation to complete their studies, increasing their willingness to participate in courses, and enhancing their awareness of employment readiness, thereby exerting a profound influence on their individual employment pathways [18]. Crişan, C. et al. pointed out that university graduates often lack sufficient understanding of employment opportunities and their own capabilities, while coherent career planning plays a crucial role in helping them formulate employment pathways and enhance their professional competitiveness [19]. In summary, career planning is particularly important for college students in the job market, as it guides their career direction, enhances their skills, and plays a significant role in improving their employment competitiveness.

This paper employs the entropy method to design an evaluation index system for the employment quality of university graduates under the context of career planning courses in higher education institutions. It further utilizes the Dagum Gini coefficient, kernel density estimation, and Markov chain models to investigate the spatial distribution and dynamic evolution of employment quality among university graduates within the framework of career planning courses. In this process, the differences in employment quality among college graduates across 13 prefecture-level cities in Jiangsu Province and the three regions of Suzhong, Sunan, and Subei were analyzed. Additionally, the stability of the employment quality tracking model based on Markov chains was analyzed.

2. Research Methods and Data Sources

2.1. Research Methods

2.1.1. Entropy Method

This paper uses the entropy value method [20] to process various indicators of the employment quality of college graduates. A normalized method is used to perform dimensionless processing on the original data. The specific formula is shown below:

$$\text{Positive indicator processing formula: } Z_{ij} = \frac{X_{ij} - \min X_{ij}}{\max X_{ij} - \min X_{ij}} \quad (1)$$

$$\text{Negative indicator processing formula: } Z_{ij} = \frac{\max X_{ij} - X_{ij}}{\max X_{ij} - \min X_{ij}} \quad (2)$$

Among them, X_{ij} is the value of the j th indicator for the i th evaluation object, and Z_{ij} is the standardized value.

The calculation formula for the entropy method is shown in Equation (3), where ω_i is the weight, m is the total number of indicators, and U is the employment quality of college graduates:

$$U = \sum_{j=1}^m Z_{ij} \times \omega_j \quad (3)$$

2.1.2. Kernel density estimation method

Kernel density estimation [21] is used to examine the dynamic evolution of the employment quality of college graduates, as shown in the following formula:

$$f(x) = \frac{1}{Nh} \sum_{i=1}^N K\left(\frac{X_i - \bar{x}}{h}\right) \quad (4)$$

$$K(x) = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{x^2}{2}\right) \quad (5)$$

In this case, $f(x)$ is the estimated value, N is the sample size, h is the bandwidth, and the smaller h is, the higher the estimation accuracy. X_i is the observed value, \bar{x} is the mean, and $K(\cdot)$ is the kernel function.

2.1.3. Dagum Gini coefficient

The Dagum Gini coefficient can be used to decompose the variance factors of the relevant index, dividing the overall variance into three parts: within-group variance G_{wa} , between-group variance G_{ab} , and excess variance G_t .

The formula for calculating the overall Dagum Gini coefficient is as follows:

$$G = \frac{\sum_{a=1}^k \sum_{b=1}^k \sum_{i=1}^{n_a} \sum_{r=1}^{n_b} |L_{ai} - L_{br}|}{2n^2 \bar{L}} \quad (6)$$

Among them, n and k represent the number of universities and regions, respectively, n_a and n_b represent the number of universities in regions a and b , respectively, L_{ai} and L_{br} represent the employment quality of graduates from university i in region a and university r in region b , respectively, and \bar{L} represents the average employment quality of university graduates.

The Gini coefficient between regions a and b and the inter-regional differences G_{ab} and G_{nb} are respectively expressed as:

$$G_{ab} = \frac{\sum_{i=1}^{n_a} \sum_{r=1}^{n_b} |L_{ai} - L_{br}|}{n_a n_b (\bar{L}_a + \bar{L}_b)} \quad (7)$$

$$G_{nb} = \sum_{a=2}^k \sum_{b=1}^{a-1} G_{ab} (P_a S_b + P_b S_a) D_{ab} \quad (8)$$

Among them, $P_a = \frac{n_a}{n}$, $S_a = \frac{n_a \bar{L}_a}{n \bar{L}}$. D_{ab} represents the relative impact of the employment quality of college graduates in regions a and b , and is calculated as follows:

$$D_{ab} = \frac{d_{ab} - p_{ab}}{d_{ab} + p_{ab}} \quad (9)$$

$$d_{ab} = \int_0^\infty dF_a(y) \int_0^y (y-x) dF_b(x) \quad (10)$$

$$p_{ab} = \int_0^\infty dF_b(y) \int_0^y (y-x) dF_a(x) \quad (11)$$

Among these, d_{ab} denotes the difference in employment quality between the two regions a and b , specifically the mathematical expectation of the sum of all sample values where $L_{ai} - L_{br} > 0$ in regions a and b . p_{ab} is the first-order hypermoment, representing the mathematical expectation of the sum of all sample values where $L_{br} - L_{ai} > 0$ in regions a and b . The formulas for the Gini coefficient G_{aa} of region a , the intra-regional disparity G_{wa} of region a , and the hyper-variability density G_t are shown in Equations (12) to (14), respectively:

$$G_{aa} = \frac{\sum_{i=1}^{n_a} \sum_{r=1}^{n_b} |L_{ai} - L_{ar}|}{2n_a^2 \bar{L}_a} \quad (12)$$

$$G_{wa} = \sum_{a=1}^k G_{aa} P_a S_a \quad (13)$$

$$G_t = \sum_{a=2}^k \sum_{b=1}^{a-1} G_{ab} (P_a S_b + P_b S_a) (1 - D_{ab}) \quad (14)$$

2.1.4. Spatial trend analysis

Spatial trend surface analysis is an important mathematical method for analyzing spatial trends. It uses abstract mathematical surfaces to simulate actual surfaces and performs spatial trend analysis on discrete spatial data to explore the distribution intensity and change trends of various spatial data in space. The essence of spatial trend surface analysis is to use regression analysis principles and the least squares method to establish a trend surface model to reveal the change patterns of various geographical elements in areal spatial regions. The formula is expressed as follows:

$$z_i(x_i, y_i) = \hat{z}_i(x_i, y_i) + \theta_i \quad (15)$$

In the equation, x_i and y_i are plane coordinates; θ_i represents the residual. A second-order polynomial is used to fit the spatial trend surface of the employment quality of college graduates.

2.1.5. Employment Status Analysis

The employment referred to in this article includes promotion, career choice, and reemployment of college graduates.

(1) Statistical period

To enable long-term tracking of graduates, the time period for surveying and calculating graduate employment quality is divided into equal intervals, each of which is referred to as a statistical cycle and denoted by T . The vector of consecutive statistical periods is denoted as $\{T_1, T_2, \dots, T_n, \dots\}$ or $\{1, 2, \dots, n, \dots\}$. If an employed individual has multiple employment instances within a statistical period, the data at the time of statistical calculation is used as the basis.

(2) Employment status

The employment quality level of an employed individual within the statistical period $[0, T]$ is referred to as the employment status. The state space is represented by $U = \{1, 2, \dots, N\}$. Let a be the number of members in a certain group, and let $a_i (i = 1, 2, \dots, N)$ be the number of people in grade i at time T_j , i.e., $a = \sum_{i=1}^N a_i$. The vector formed by the ratio of the number of people in each level to the total number of people, $\left\{ \frac{a_1}{a}, \frac{a_2}{a}, \dots, \frac{a_N}{a} \right\}$, is called the employment status distribution vector of the group at period T_j and is denoted by X_{T_j} . The state distribution vector of graduates at the time of their first employment is generally referred to as the initial vector, denoted by X_0 , which represents the employment grade ratio distribution at the time of first employment.

(3) Employment transition

An employed person moves from employment status i to status j after a period of time t , i.e., an employed person is at level i during period T_k and becomes level j after a period of time t . When $i < j$, it indicates that the employed person has entered a higher level through efforts over a period of time t , such as promotion or changing jobs. When $i = j$, it indicates that the worker remains at the original level. When $i > j$, it indicates that the worker has moved to a lower level, which may be due to insufficient effort, poor conditions at the employer, or inappropriate career choices. Here, we do not consider whether the worker is employed at a single employer; we only emphasize that the quality indicators meet the corresponding level. When $t = T_1$, it is called a single-step transition; when $t = T_1 + T_2 + \dots + T_k$, it is called a k -step transition.

For the employment status X_{T_n} , there is an independent distribution at each statistical cycle, and there are corresponding transitions between statistical cycles. Thus, $\{X_{T_n}\}$ forms a Markov chain, denoted as $\{X_n, n \geq 0\}$ or $\{X_n\}$ [22].

(4) Employment stability

As age increases and factors such as career and family come into play, the secondary job-seeking cycle for graduates will significantly lengthen and eventually stabilize.

2.1.6. Markov Chain-based Employment Quality Tracking Model

(1) Transition matrix

Let the Markov chain be $\{X_n\}$ and the state space be $U = \{1, 2, \dots, N\}$. The probability distribution of the initial employment status of the employment group is $X_0 = (p_1^{(0)}, p_2^{(0)}, \dots, p_N^{(0)})$.

Then, the state probability matrix for a single transition is:

$$P = P^{(1)} = \begin{pmatrix} p_{11}(1) & p_{12}(1) & p_{13}(1) & \cdots & p_{1N}(1) \\ p_{21}(1) & p_{22}(1) & p_{23}(1) & \cdots & p_{2N}(1) \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ p_{(N-1)1}(1) & p_{(N-1)2}(1) & p_{(N-1)3}(1) & \cdots & p_{(N-1)N}(1) \\ p_{N1}(1) & p_{N2}(1) & p_{N3}(1) & \cdots & p_{NN}(1) \end{pmatrix} \quad (16)$$

where $p_{ij}(1) \geq 0$ and $\sum_{i=1}^N p_{ij}(1) = 1$.

(2) Steady-state probability distribution

Since employed individuals can randomly move between employment quality levels, the employment status U is a state class. For any $i, j \in U$, there exists a positive integer m . When $p_{ij}(m) \geq 0$, the Markov chain is ergodic, and the steady-state distribution is:

$$\pi = (\pi_1, \pi_2, \dots, \pi_N) \quad (\pi_j > 0, j \in U) \quad (17)$$

It is the unique non-negative solution to the following system of equations:

$$\begin{cases} \pi_j = \sum_{i=1}^N \pi_i p_{ij}(1), & j \in U \\ \sum_{i=1}^N \pi_i = 1 \end{cases} \quad (18)$$

Let the chain at steady state be X . The expected value and variance of the steady-state employment quality grade are:

$$EX = \sum_{i=1}^N i\pi_i, \quad DX = \sum_{i=1}^N \pi_i (i - EX)^2 \quad (19)$$

By analyzing the distribution and numerical characteristics at steady state, we can understand the employment structure, overall employment level, and internal differences of the employment group.

(3) Number of transfers

According to Chapman-Kolmogorov's theorem, when the one-step transition probability matrix P is known, the k -step transition probability matrix is:

$$P^{(k)} = P^k, \quad k = 2, 3, \dots \quad (20)$$

Starting from the first job, perform k steps of transition. The probability distribution of the employment status at the k th step is:

$$(p_1^{(k)}, p_2^{(k)}, \dots, p_N^{(k)}) = (p_1^{(0)}, p_2^{(0)}, \dots, p_N^{(0)}) P^k \quad (21)$$

Equation (21) is called the employment state transition equation. Using Matlab mathematical software, the employment transition matrix $P^{(k)}$ is calculated for different values of k , and the probability distribution sequence of employment states for each period is as follows:

$$\left(p_1^{(1)}, p_2^{(1)}, \dots, p_N^{(1)} \right), \left(p_1^{(2)}, p_2^{(2)}, \dots, p_N^{(2)} \right), \dots, \left(p_1^{(k)}, p_2^{(k)}, \dots, p_N^{(k)} \right) \quad (22)$$

Find the expected value of each period $EX_k = \sum_{i=1}^N iP_i^{(k)}$. Given a confidence level λ , compare it with the expected value of the stationary distribution $\pi = (\pi_1, \pi_2, \dots, \pi_N)$. We have:

$$|EX_k - EX| < 1 - \lambda \quad (23)$$

The minimum value of k that satisfies equation (23) is the minimum number of transfer steps required from initial employment to near steady state.

(4) Tracking Adjustment

To accelerate employment transitions, adjustments can be made immediately after obtaining data from a single transition. The transition matrix for the second cycle after adjustment is set to $P'_{(2)}$, and the transition operation is performed again using equation (20) to calculate the corresponding expected values. These values are compared with the data before adjustment. If the results are satisfactory, tracking adjustments can continue; otherwise, the reasons must be analyzed to determine the effectiveness of the strategy.

(5) Expected time to employment goal

If Level 1 is the employment goal for job seekers, let $t(2), t(3), \dots, t(N)$ represent the expected times for graduates of Levels 2, 3, ..., N to achieve their goals in their first employment, and $t(1)$ represent the expected time for graduates initially transferred from Level 1 to other levels to achieve their goals again. Then the time model is:

$$\begin{cases} t(1) = 1 + p_{12}t(2) + p_{13}t(3) + \dots + p_{1N}t(N) \\ t(2) = 1 + p_{22}t(2) + p_{23}t(3) + \dots + p_{2N}t(N) \\ t(3) = 1 + p_{32}t(2) + p_{33}t(3) + \dots + p_{3N}t(N) \\ \dots \\ t(N) = 1 + p_{N2}t(2) + p_{N3}t(3) + \dots + p_{NN}t(N) \end{cases} \quad (24)$$

In the formula, 1 represents the time period of one statistical cycle used in the second statistical survey for graduates who were in grades 2, 3, ..., N when they first entered the workforce.

Between the two employment surveys, downgrades occur infrequently, and the rate of decline in employment grade can be approximated as zero, i.e., when $j > i$, $p_{ij} = 0$. The transition matrix is:

$$P = \begin{pmatrix} p_{11} & 0 & 0 & \dots & 0 \\ p_{21} & p_{22} & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots \\ p_{(N-1)1} & p_{(N-1)2} & p_{(N-1)3} & \dots & 0 \\ p_{N1} & p_{N2} & p_{N3} & \dots & p_{NN} \end{pmatrix} \quad (25)$$

The expected time model for first-time employment of Level 2, 3, ..., N graduates to reach their goals is as follows:

$$\begin{cases} t(2) = 1 + p_{22}t(2) \\ t(3) = 1 + p_{32}t(2) + p_{33}t(3) \\ \dots \\ t(N) = 1 + p_{N2}t(2) + p_{N3}t(3) + \dots + p_{NN}t(N) \end{cases} \quad (26)$$

Let $H = (t(2) \ t(3) \ \cdots \ t(N))$, the transition matrix between non-target grades for graduates is $M = (p_{ij}) (i \geq 2, j \geq 2)$, then the matrix form of equation (26) is $H = MH + I$. Solving the equation yields the time matrix for graduates staying at each grade:

$$H = (I - M)^{-1} \quad (27)$$

The retention time matrix shows how long it takes for graduates who did not enter the top tier to reach the top or higher tiers.

2.2. Indicator Selection and Data Description

To investigate the impact of career planning courses in higher education institutions on graduates' employment pathways, this study takes 13 prefecture-level cities in Jiangsu Province, China, as its research subjects and selects employment-related data for university graduates from 2013 to 2023 under the course implementation environment. All original data sources are from the "China Urban Statistical Yearbook," "Jiangsu Statistical Yearbook," "Jiangsu Provincial Government Work Report," and the statistical bulletins on national economic and social development of various prefecture-level cities in Jiangsu Province. Missing values in individual data were handled using a three-year moving average method.

Regarding the construction of the employment quality indicator system for university graduates in Jiangsu Province, this study, based on relevant scholars' research and considering principles such as data availability and feasibility, ultimately selected four first-level indicators, 13 second-level indicators, and 31 third-level indicators to measure the employment quality of university graduates in each prefecture-level city annually. The employment quality evaluation indicator system for university graduates is shown in Table 1. Using the entropy method, the weights of the evaluation indicator system are calculated as shown in Table 2. Among the four primary indicators, the weights of employment status and graduate feedback and evaluation are relatively higher, indicating that the actual employment status of graduates and their subjective perceptions of employment are more important in evaluating graduate employment quality.

Table 1. Evaluation index system for the employment quality of university graduates.

First-level indicator	First-level indicator	Third-level indicators	Code
Employment environment (A ₁)	Economic development (B ₁)	Per capita GDP	C ₁
		Economic growth rate	C ₂
		Employment elasticity coefficient	C ₃
	Social security (B ₂)	Social security coverage	C ₄
		Minimum wage standard	C ₅
	Employment supply and demand (B ₃)	The ratio of supply and demand of the labor force	C ₆
		The supply-demand ratio of job positions for college graduates	C ₇
	Employment service (B ₄)	Public employment service system	C ₈
		The informatization level of employment services	C ₉
Employment situation (A ₂)	Employment rate (B ₅)	Initial employment rate	C ₁₀
		Year-end employment rate	C ₁₁
	Employment structure (B ₆)	The proportion of employment in government public institutions	C ₁₂
		The proportion of employment in state-owned enterprises	C ₁₃
		The proportion of employment in non-state-owned enterprises	C ₁₄
		Proportion of self-employment	C ₁₅
		The rate of further education	C ₁₆
Subjective evaluation of employers (A ₃)	Employer satisfaction (B ₇)	Annual assessment	C ₁₇
		Overall satisfaction with graduates	C ₁₈
	Employability achievement degree (B ₈)	Personal quality	C ₁₉
		Working ability	C ₂₀
		Knowledge reserve	C ₂₁

Feedback and evaluation of graduates (A ₄)	Compensation and Benefits (B ₉)	Salary level	C ₂₂
		Employee training	C ₂₃
	Professional relevance (B ₁₀)	Professional relevance	C ₂₄
		Professional matching rate	C ₂₅
	Work stability (B ₁₁)	Conversion rate of work units	C ₂₆
		The number of times one changes their work unit	C ₂₇
	Employment guarantee (B ₁₂)	Social insurance participation level	C ₂₈
		Contract signing ratio	C ₂₉
	Job satisfaction (B ₁₃)	Graduate employment satisfaction	C ₃₀
		The degree of achievement of graduates' employment intentions	C ₃₁

Table 2. Weights of employment quality evaluation indicators for university graduates.

First-level indicator	Weight	First-level indicator	Weight	Third-level indicators	Weight
A ₁	0.21	B ₁	0.27	C ₁	0.38
				C ₂	0.33
				C ₃	0.29
		B ₂	0.21	C ₄	0.52
				C ₅	0.48
		B ₃	0.32	C ₆	0.49
				C ₇	0.51
		B ₄	0.20	C ₈	0.48
				C ₉	0.52
A ₂	0.29	B ₅	0.58	C ₁₀	0.43
				C ₁₁	0.57
		B ₆	0.42	C ₁₂	0.22
				C ₁₃	0.21
				C ₁₄	0.20
				C ₁₅	0.19
A ₃	0.22	B ₇	0.51	C ₁₆	0.18
				C ₁₇	0.48
		B ₈	0.49	C ₁₈	0.52
				C ₁₉	0.32
				C ₂₀	0.37
A ₄	0.28	B ₉	0.32	C ₂₁	0.31
				C ₂₂	0.62
		B ₁₀	0.11	C ₂₃	0.38
				C ₂₄	0.53
				C ₂₅	0.47
		B ₁₁	0.12	C ₂₆	0.54
				C ₂₇	0.46
		B ₁₂	0.18	C ₂₈	0.57
				C ₂₉	0.43
		B ₁₃	0.27	C ₃₀	0.72
C ₃₁	0.28				

3. Empirical research and analysis of results

3.1. Analysis of the results of measuring the quality of employment among college graduates

This chapter uses the established evaluation index system to measure the employment quality of graduates in Jiangsu Province who have taken career planning courses. The results of the measurement of the employment quality of college graduates in various prefecture-level cities are shown in Table 3. Due to space limitations, only the results for some years are listed.

Table 3. Measurement results of the employment quality of college graduates.

Prefecture-level city	Region	2013	2018	2023
Nanjing	Southern Jiangsu	0.455	0.652	0.652
Wuxi	Southern Jiangsu	0.579	0.604	0.638
Suzhou	Southern Jiangsu	0.627	0.722	0.655
Changzhou	Southern Jiangsu	0.493	0.565	0.647
Zhenjiang	Southern Jiangsu	0.434	0.563	0.694
Nantong	Central Jiangsu	0.484	0.562	0.614
Yangzhou	Central Jiangsu	0.449	0.584	0.682
Taizhou	Central Jiangsu	0.421	0.577	0.631
Xuzhou	Northern Jiangsu	0.301	0.483	0.517
Lianyungang	Northern Jiangsu	0.234	0.327	0.467
Huai'an	Northern Jiangsu	0.397	0.413	0.573
Yancheng	Northern Jiangsu	0.456	0.525	0.666
Suqian	Northern Jiangsu	0.207	0.354	0.444
	Southern Jiangsu	0.518	0.621	0.657
	Central Jiangsu	0.451	0.574	0.642
	Northern Jiangsu	0.319	0.420	0.533

To get a clearer and more dynamic picture of the spatial pattern of employment quality for college grads in Jiangsu Province, and considering that 2013 was the starting year for observation, we picked 2013, 2018, and 2023 as observation points for analysis. Using ArcGIS software, we made a spatiotemporal evolution map of employment quality for college grads in Jiangsu Province, as shown in Figure 1. We can see that the comprehensive evaluation index of employment quality for college grads in Jiangsu Province has obvious spatial differences.

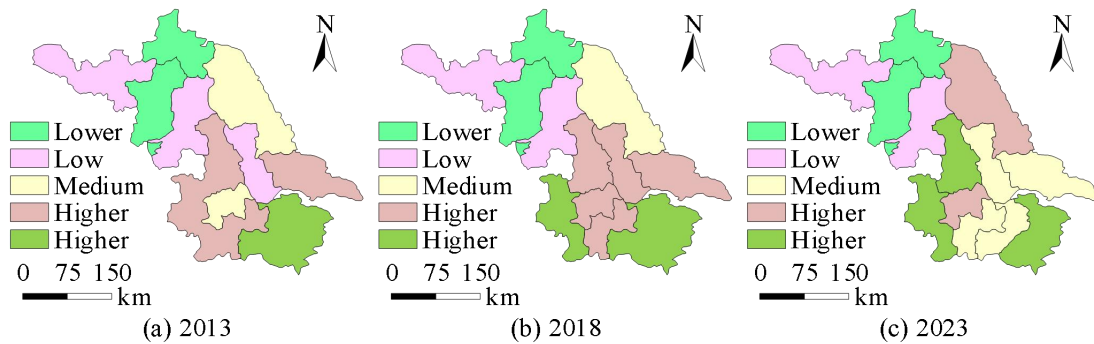


Figure 1. The spatio-temporal evolution of the employment quality of college graduates.

Meanwhile, the statistical analysis of the development trends in the employment quality of university graduates in Jiangsu Province is shown in Figure 2. The bar chart represents the comprehensive evaluation index of graduate employment quality, while the line chart shows the average annual growth rate across different regions. From the temporal evolution characteristics, the employment quality of university graduates in Jiangsu Province has developed rapidly from 2013 to 2023. From the perspective of the comprehensive evaluation index of employment quality for university graduates, from 2013 to 2023, the employment quality of graduates in the southern Jiangsu region was generally high, with Suzhou and Nanjing ranking at the top. The comprehensive evaluation index of employment quality for university graduates in the central Jiangsu region increased from 0.451 in 2013 to 0.642, exceeding the provincial average by 5.97%, with Yangzhou developing relatively quickly. The employment quality of college graduates in the northern Jiangsu region is relatively low, with the comprehensive evaluation indices of Suqian and Lianyungang cities both below 0.47. From the trend of growth rate changes, there was a noticeable downward trend during the two periods of 2016-2018 and 2020-2022, which may be attributed to the gradual transition of the economy from high-speed growth to high-quality development, as well as the combined effects of external competitive pressures and internal environmental pressures.

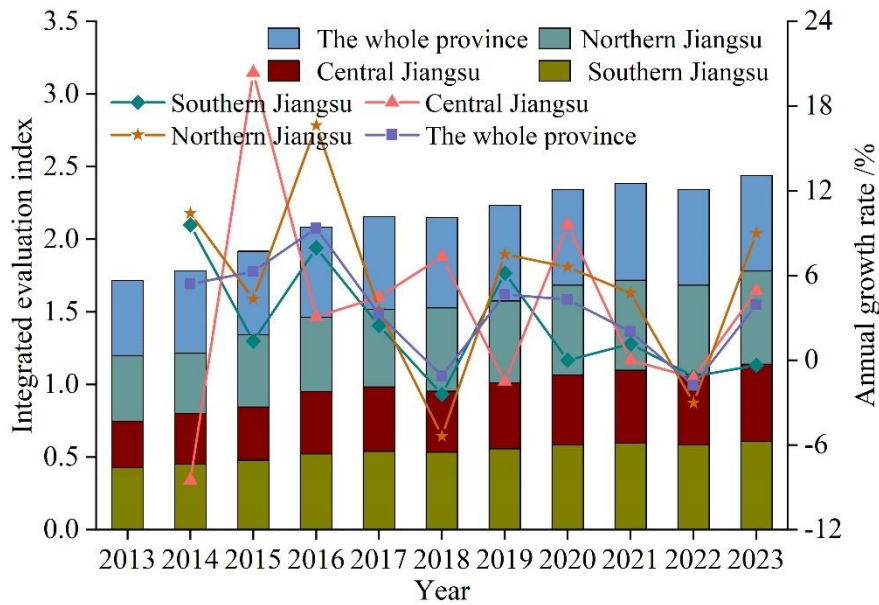


Figure 2. The development and evolution trend of the employment quality of graduates.

3.2. Regional Differences in the Quality of Employment for College Graduates and Their Sources

To further explore the spatial differences in the distribution of employment quality among college graduates in Jiangsu Province, the Gini coefficient and decomposition results for the employment quality of graduates in Jiangsu Province from 2013 to 2023 are shown in Table 4. Among them, SJ, CJ, and NJ represent the abbreviations for the three regions of Southern Jiangsu, Central Jiangsu, and Northern Jiangsu, respectively.

Table 4. The Gini coefficient of employment quality of graduates and its decomposition.

Year	Overall coefficient	The Gini coefficient within the region			Inter-regional Gini coefficient			Contribution rate /%		
		SJ	CJ	NJ	SJ-CJ	SJ-NJ	CJ-NJ	Within the region	Between regions	Supervariable density
2013	0.139	0.058	0.036	0.165	0.075	0.235	0.163	23.59	74.49	2.24
2014	0.125	0.064	0.049	0.143	0.116	0.211	0.136	22.35	74.67	2.48
2015	0.135	0.068	0.019	0.139	0.083	0.218	0.144	20.71	77.85	0.63
2016	0.132	0.080	0.001	0.123	0.091	0.197	0.112	24.95	67.78	6.65
2017	0.114	0.064	0.032	0.128	0.056	0.166	0.132	23.52	70.64	3.75
2018	0.123	0.051	0.006	0.114	0.055	0.185	0.163	18.83	80.22	0.36
2019	0.108	0.038	0.018	0.081	0.052	0.143	0.115	22.29	75.84	1.66
2020	0.112	0.041	0.052	0.079	0.055	0.142	0.125	22.89	68.57	10.12
2021	0.072	0.031	0.032	0.071	0.042	0.129	0.122	21.08	75.46	4.48
2022	0.064	0.019	0.013	0.094	0.031	0.124	0.142	20.96	74.30	5.14
2023	0.061	0.014	0.015	0.086	0.022	0.119	0.114	21.25	71.36	6.62

3.2.1. Overall gaps and trends in their evolution

Based on Table 4, the Gini coefficient trend for the employment quality of college graduates in Jiangsu Province from 2013 to 2023 is illustrated in Figure 3. Overall, the Gini coefficient shows a fluctuating downward trend. Using 2013 as the base year, the coefficient decreased from 0.139 in 2013 to a minimum of 0.061 in 2023, with an average annual decrease of 5.61%, indicating a significant downward trend. This suggests that the disparity in employment quality among college graduates in Jiangsu Province is gradually narrowing.

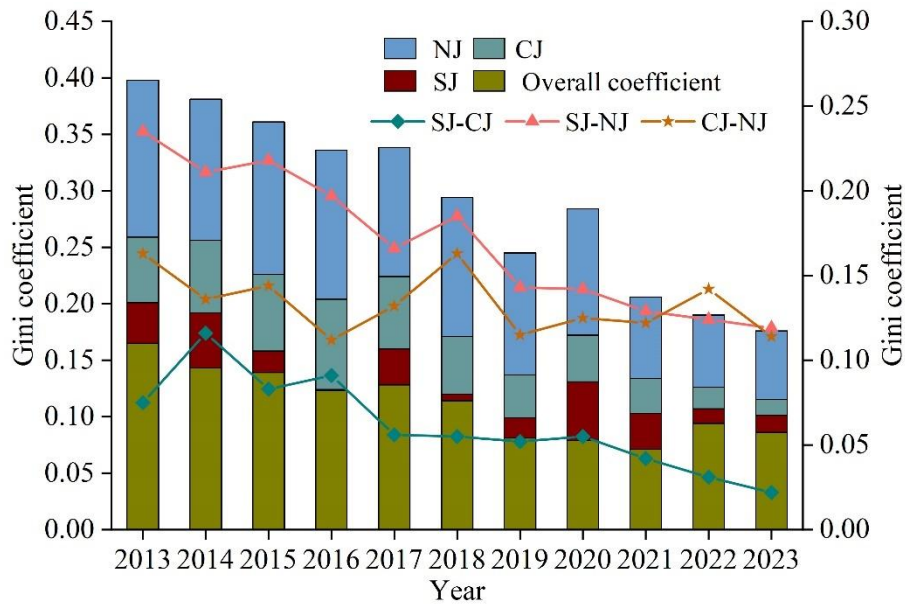


Figure 3. The evolution trend of the Gini coefficient.

3.2.2. Regional disparities and trends in their evolution

As shown in Figure 3, the Gini coefficients for the regions of Southern Jiangsu, Central Jiangsu, and Northern Jiangsu exhibit distinct trends over time. Specifically, the quality of employment for college graduates in the Suzhou North region has consistently been higher than in the other two regions, indicating that there are still significant differences in the quality of employment for college graduates within the region. In the Suzhou Central region, the quality of employment for college graduates has been at the lowest level in most years, with the exception of 2020, 2021, and 2023, when it was slightly higher than in the Suzhou South region. Over the past decade, the Gini coefficient has never exceeded 0.06, indicating that the quality of employment for college graduates in the Suzhou Central region has remained relatively stable. The employment quality disparity among college graduates in the southern Jiangsu region has generally been between the other two regions in most years, with the exception of 2020, 2021, and 2023, when it was slightly lower than that of the central Jiangsu region. Its Gini coefficient has fluctuated downward, reaching a minimum of 0.014 in 2023, with an average annual decrease of 7.59%. Overall, the Gini coefficients in all regions have been continuously decreasing, indicating that with the government's reforms and governance, the employment quality disparity among college graduates within regions is gradually narrowing.

3.2.3. Regional disparities and trends in their evolution

From the perspective of inter-regional trends, the Gini coefficient between regions in Jiangsu Province has shown a fluctuating downward trend. The disparity in employment quality among college graduates between the southern and northern regions of Jiangsu Province has remained at the highest level, except in 2022, followed by the central and northern regions. The disparity in employment quality among college graduates between the southern and central regions is the smallest. Specifically, the difference in full employment levels between the southern and central regions of Jiangsu Province has followed a “three increases and three decreases” trend. If 2016 is taken as the base year, the annual average decrease is 10.83%, indicating a very rapid decline, which suggests that the difference between the southern and central regions of Jiangsu Province is narrowing. The quality of employment for college graduates between the Suzhong-Subei regions remains relatively stable. After a slight decline, the regional differences have fluctuated around the average of 0.122. The quality of employment for college graduates between the Sunan-Subei regions has gradually decreased over time, with regional differences increasing only in 2015 and 2018.

3.2.4. Sources of regional disparities and their contribution rates

Based on Table 4, the contribution rates of employment quality differences among college graduates in Jiangsu Province are illustrated in Figure 4. Overall, the contribution rate of intra-regional differences

(G_{wr}) remains relatively stable, while the contribution rates of inter-regional differences (G_{br}) and super-variability density (G_{sd}) exhibit significant fluctuations. In terms of the trend in contribution rates, the G_{wr} contribution rate has remained relatively stable, showing a slight downward trend. The G_{br} contribution rate and G_{sd} contribution rate exhibit a “three-down, three-up” trend. Using 2013 as the base year, the changes in the G_{wr} , G_{br} , and G_{sd} contribution rates by 2023 were -2.34%, -3.13%, and +4.38%, respectively. Based on the magnitude of the contribution rates, the average contribution rates of G_{wr} , G_{br} , and G_{sd} for the employment quality of university graduates in Jiangsu Province from 2013 to 2023 were 22.04%, 73.74%, and 4.01%, respectively. Additionally, the change curves of the three contribution rates did not intersect during the sample observation period. It can thus be concluded that the primary source of overall differences in the employment quality of university graduates in Jiangsu Province is inter-regional differences, followed by intra-regional differences, and finally super-variable density.

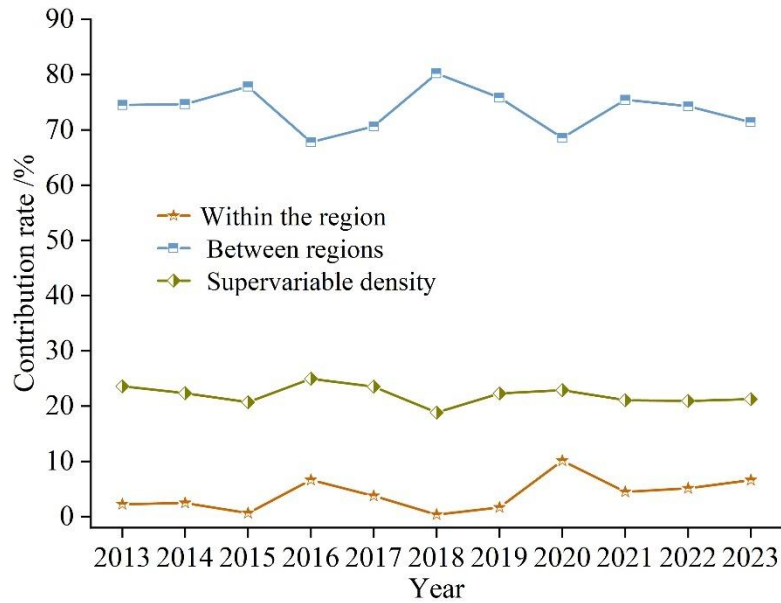
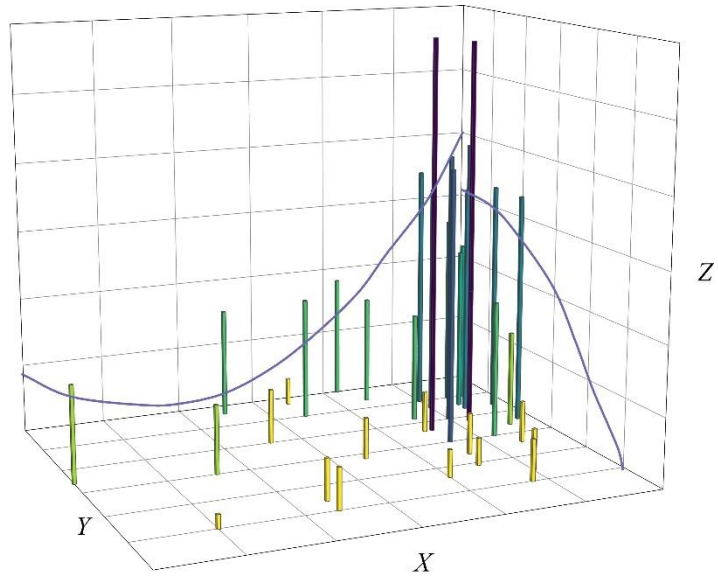


Figure 4. Contribution rate of employment quality differences among college graduates.

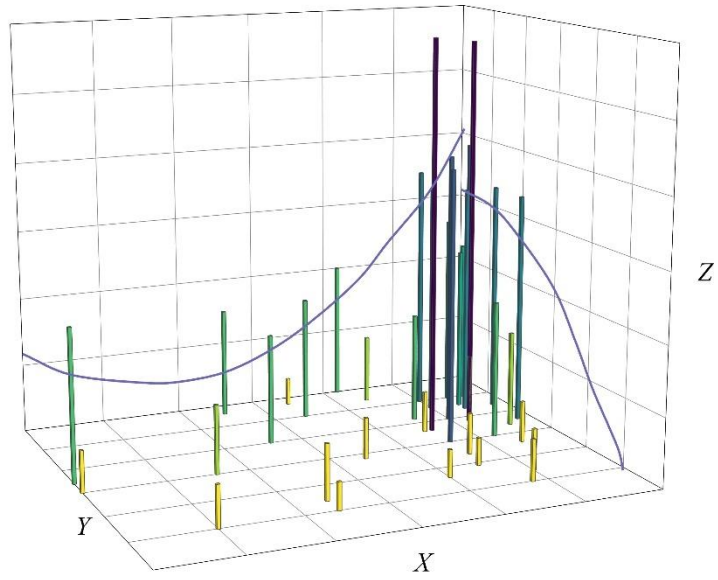
3.3. Dynamic Evolution of the Distribution of Employment Quality Among College Graduates

3.3.1. Spatial Pattern Characteristics

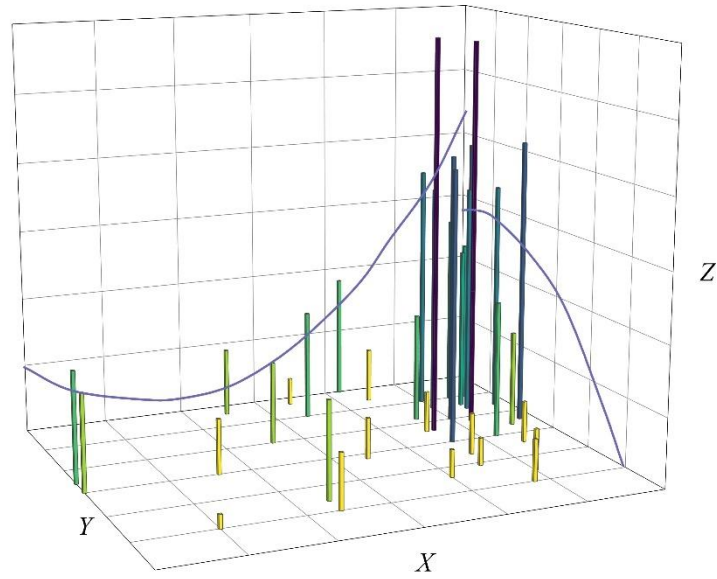
To reveal the spatial distribution pattern of employment quality among college graduates in Jiangsu Province at the county level, this paper utilizes trend analysis tools to map the employment quality of college graduates in each county in 2013, 2018, and 2023 as height attribute values, creating a three-dimensional perspective diagram as shown in Figure 5. (a) to (c) represent the spatial distributions for 2013, 2018, and 2023, respectively. From the shapes of the trend curves across the three time periods, the trend curves exhibit a “U”-shaped pattern in the east-west direction, with higher values in the east and west and lower values in the central region, indicating that the employment quality of university graduates in the eastern and western regions of Jiangsu Province is higher than that in the central region. In the north-south direction, the trend curves show a smooth decline from south to north, indicating that during the study period, the employment quality of university graduates in Jiangsu Province formed a distribution pattern with higher values in the south and lower values in the north. Possible reasons include the fact that the southeastern part of Jiangsu Province has flat terrain, is close to the sea, and has a high concentration of large enterprises, resulting in a relatively developed economy and a greater number of available job positions, thereby leading to higher employment quality for university graduates. Counties in the southwestern region, with abundant natural resources, have attracted a large influx of labor, promoting the development of employment quality for college graduates in the area. In contrast, the northern part of Jiangsu Province is primarily an agricultural region with lagging transportation infrastructure and severe population outflow, which has to some extent constrained the development of employment quality for college graduates.



(a) 2013



(b) 2018



(c) 2023

Figure 5. Trend lines of the employment quality in Jiangsu province.

To further characterize the spatial patterns of employment quality for university graduates in Jiangsu Province at the county level, this study employs standard deviation ellipses, selecting three time points—2013, 2018, and 2023—to quantitatively identify evolutionary trends. The specific parameters of the standard deviation ellipses are shown in Table 5.

From the perspective of the angle of rotation, the angle of rotation of the standard deviation ellipse for the spatial distribution of employment quality among university graduates in Jiangsu Province decreased from 86.46° in 2013 to 74.68° in 2023, showing a gradually narrowing trend. This indicates that the spatial distribution of employment quality among university graduates in Jiangsu Province has shifted from an “east-west” distribution to a “southeast-northwest” direction. From the perspective of the shape of the standard deviation ellipse, the average shape index decreased slightly from 2013 to 2018 and then increased slightly from 2018 to 2023, indicating that the distribution trend of the employment quality of university graduates in Jiangsu Province during the study period first dispersed and then concentrated. From the perspective of the center of gravity distribution, the center of gravity of the employment quality of university graduates in Jiangsu Province fluctuated between 118.62° - 118.84° E and 33.25° - 33.52° N during the study period, with a small movement amplitude, slightly shifting toward the southwest direction.

Table 5. Specific parameters of the standard deviation ellipse.

Year	Angle of rotation / $^\circ$	Average shape index	Center of gravity coordinate
2013	86.46	0.53	118.84° E, 33.52° N
2018	83.05	0.45	118.67° E, 33.43° N
2023	74.68	0.48	118.62° E, 33.25° N

3.3.2. Dynamic evolution based on Kernel density estimation

Based on the comprehensive evaluation index of employment quality for college graduates in Jiangsu Province, a three-dimensional kernel density estimate map of Jiangsu Province is shown in Figure 6. Overall, the distribution of employment quality for college graduates in Jiangsu Province has shifted to the left, with the right tail becoming shorter and shorter. The narrow, tall main peak and the left side peak have gradually evolved into a shorter main peak and a left side peak, indicating that the differences in employment quality for college graduates in Jiangsu Province have decreased, but there is still a significant multi-polar differentiation phenomenon.

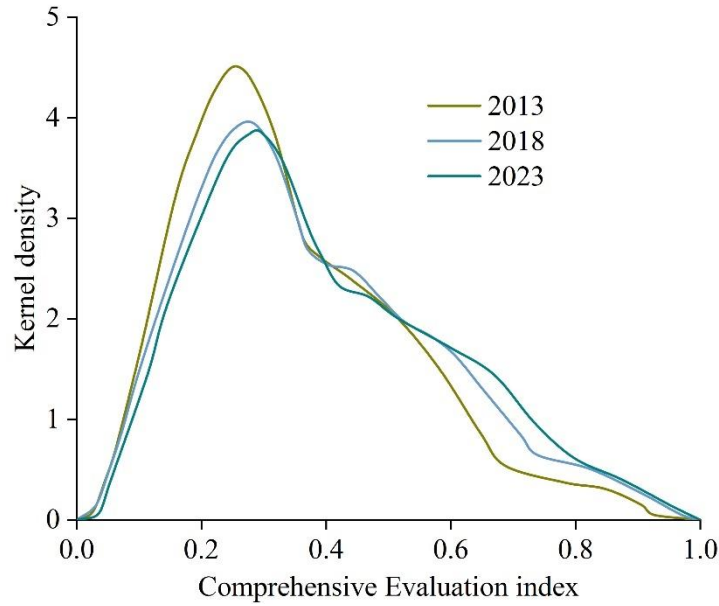


Figure 6. Estimation results of Kernel density in Jiangsu province.

3.3.3. Spatial Markov Chain Analysis

The traditional Markov chain transition probability matrix treats each region as an independent unit. It fails to consider the influence of surrounding area types on its transitions. Therefore, this paper incorporates spatial factors into the traditional Markov matrix framework. By constructing a spatial Markov matrix, it analyzes the impact of different neighboring area types on the transition of employment quality for university graduates. The spatial Markov chain transition probability matrix for the employment quality of university graduates in Jiangsu Province from 2013 to 2023 is shown in Table 6.

(1) Spatial factors have a significant influence on the club convergence changes in the employment quality of university graduates in Jiangsu Province. When spatial factors are ignored, the probability of Type III maintaining its original level remains unchanged at 0.851. However, when spatial factors are considered, the probabilities of Type III maintaining its original level in Neighborhood Types I, II, III, and IV are 0.000, 0.873, 0.837, and 0.842, respectively.

(2) After considering spatial factors, the employment quality of college graduates in Jiangsu Province still exhibits stable club convergence characteristics. The probability values along the diagonal are higher than those at other positions. Only under the Type II neighborhood context does the probability of Type IV maintaining its original state equal the probability of its transition to Type II, indicating that even when considering the neighborhood type context, counties still tend to maintain their current stable state.

(3) In the process of the development of the employment quality of college graduates, there is usually a spatial spillover effect. If it is adjacent to a county with a higher employment quality of college graduates, the probability of upward transfer of county type increases, and the probability of downward transfer decreases. Adjacent to the county with low employment quality of college graduates, the probability of upward transfer of county type decreases and the probability of downward transfer increases, indicating that the adjacent county has a positive spatial spillover effect on the county. Specifically, the transition probability from type III to type IV is 0.095, which increases to 0.132 and 0.175 when adjacent to type III and type IV., and decreases to 0.000 and 0.036 when adjacent to type I and type II. The reason may be that the middle and high-level counties have a demonstration effect in resource utilization and industrial development, and can play a leading role in radiating and driving neighboring counties.

Table 6. Spatial Markov transition probability matrix.

Neighborhood type	County type	I	II	III	IV
I	I	0.912	0.087	0.021	0.000
	II	0.000	1.000	0.000	0.000
	III	0.000	0.000	0.000	0.000
	IV	0.000	0.000	0.000	0.000
II	I	0.817	0.183	0.032	0.000
	II	0.086	0.864	0.045	0.036
	III	0.000	0.117	0.873	0.036
	IV	0.000	0.512	0.000	0.512
III	I	1.000	0.000	0.000	0.000
	II	0.000	0.785	0.234	0.000
	III	0.000	0.061	0.837	0.132
	IV	0.000	0.000	0.072	0.941
IV	I	0.000	0.000	0.000	0.000
	II	0.000	0.000	0.000	0.000
	III	0.000	0.000	0.842	0.175
	IV	0.000	0.000	0.019	0.992

3.4. Stability Analysis of the Employment Quality Tracking Model

Let the five employment levels be $X = \{1, 2, 3, 4, 5\}$, the expected value of the employment quality level in steady state is $EX = \sum_{i=1}^5 i\pi_i$, and the mathematical expectation $EX = 1.6054$ indicates that the average employment status is between excellent and good. Using $p_j^{(n)} = \sum_{i \in E} p_i p_{ij}^{(n)}$ ($j \in E$) and the initial distribution $p_1^{(0)} = p(0) = \{0.07, 0.13, 0.25, 0.34, 0.27\}$, the results are obtained under the condition of career planning courses. Table 7 shows the probability distribution and mathematical expectation of each employment status of college graduates in the first 10 years. Where: $p_1^{(n)}, p_2^{(n)}, p_3^{(n)}, p_4^{(n)}, p_5^{(n)}$ denotes the absolute probability of being in each state in the first year of n , and $EX_n = \sum_{j=1}^5 j p_j^{(n)}$.

It can be seen that when the confidence level is 95%, $|EX_n - EX| \leq 0.05$, you can get $n = 7$ to achieve stability after that. That is, after about 7 years, the employment status can be close to the steady state, that is, although the employment quality is not satisfactory at the beginning, after 7 years, the probability distribution of each employment status will gradually stabilize and will eventually remain unchanged.

Table 7. The probability distribution and expected deviation of employment in each state.

Graduation time	$p_1^{(n)}$	$p_2^{(n)}$	$p_3^{(n)}$	$p_4^{(n)}$	$p_5^{(n)}$	EX_n	$ EX_n - EX $
1	0.1380	0.2219	0.2755	0.1998	0.1582	2.9745	1.4864
2	0.2342	0.2968	0.2596	0.0956	0.0963	2.4588	0.9815
3	0.3057	0.3469	0.2324	0.0769	0.0588	2.0432	0.5282
4	0.3547	0.3791	0.2019	0.0623	0.0489	1.9612	0.4364
5	0.4245	0.3714	0.1591	0.0408	0.0236	1.8624	0.2788
6	0.4488	0.3671	0.1412	0.0304	0.0134	1.7715	0.1877
7	0.4964	0.3735	0.1183	0.0246	0.0082	1.6576	0.0464
8	0.5125	0.3083	0.1198	0.0209	0.0056	1.6012	0.0163
9	0.5355	0.3724	0.1134	0.0127	0.0043	1.5936	0.0177
10	0.5307	0.3813	0.0951	0.0101	0.0031	1.5635	0.0183

4. Conclusion

This paper employs methods such as entropy analysis, the Dagum Gini coefficient, kernel density estimation, and Markov chain models to investigate the impact of career planning courses in higher education institutions on graduates' employment pathways. The research findings are as follows:

(1) The comprehensive evaluation index of employment quality for university graduates in Jiangsu Province exhibits significant spatial differences. Among these, the employment quality differences among university graduates in the northern region of Jiangsu have consistently been higher than those in the central and southern regions. However, overall, the employment quality differences within regions are gradually decreasing.

(2) In terms of inter-regional disparities, the largest differences in employment quality among university graduates are between the southern and northern regions of Jiangsu Province, followed by the central and northern regions, and finally the southern and central regions. Overall, the Gini coefficients across regions in Jiangsu Province show a fluctuating downward trend, indicating that inter-regional disparities are gradually narrowing.

(3) Using 2013 as the base year, the contribution rates of intra-regional differences, inter-regional differences, and hyper-variability density in Jiangsu Province in 2023 changed by -2.34%, -3.13%, and +4.38%, respectively, with corresponding average contribution rates of 22.04%, 73.74%, and 4.01%. This indicates that the primary source of overall differences in the employment quality of college graduates in Jiangsu Province is inter-regional differences, followed by intra-regional differences, and finally super-variable density.

(4) The employment quality of college graduates in Jiangsu Province exhibits a distribution pattern of "high in the east and west, low in the central region" and "high in the south, low in the north," and between 2013 and 2023, the distribution shifted from "east-west" to "southeast-northwest."

(5) After approximately seven years, the employment status of university graduates approaches a steady state, meaning that the probability distributions of various employment statuses gradually stabilize and ultimately remain unchanged.

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