Temporal and Spatial Trajectories of the Economic and Pollution Emission Focus of China's Textile Industry

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Abstract: Correctly handling the relationship between economic development and pollution emissions in the textile industry is an important basis for achieving green and sustainable economic development in the textile industry. This paper takes the textile industry as the research object, selects the textile industry micro data from 1998 to 2013, firstly uses the centre of gravity model to explore the spatial and temporal trajectory of the centre of gravity of the textile industry's economy and pollution emission; then uses the grey correlation method to measure the correlation between the textile industry and six sub-sectors in two dimensions of economic development and pollution emission; finally uses the centre of gravity coupling posture model to explore the coupling posture of the centre of gravity of the textile industry's economy and the centre of gravity of pollution emission The results show that: (1) from 1998 to 2013, the economic centre of gravity of the textile industry was always located within the Anhui provincial boundary; and the output value of the cotton, chemical fibre textile and dyeing and finishing industries had the greatest impact on the economic growth of the textile industry. (2) The centre of gravity of the textile industry's pollution emissions from 1998-2013 moved along Shanxi-Henan-Hubei-Shaanxi to the western region; the pollution emissions from the manufacture of textile manufactured goods and the cotton, chemical fibre textile and dyeing finishing industries were the main factors causing the pollution problems in the textile industry; (3) From 1998 to 2013, the coupling between the textile economy and the centre of gravity of pollution emissions showed a "W"-shaped trend change, and was influenced by the strategy of shifting the centre of gravity of the textile industry to the west. The purpose of this paper is to provide theoretical suggestions for the green development of the textile industry economy by studying the relationship between the textile industry economy and the focus of pollution emissions.

Keywords: Textile Industry; Economic Focus; Pollution Emission Focus; Spatial and Temporal Trajectories; Coupling Dynamics

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1 Introduction

China Environmental Statistics Yearbook shows that in 2020, chemical oxygen demand emissions from textile wastewater were 60,600 tons and ammonia nitrogen emissions were 0.18 million tons, accounting for 23.94% and 20.00% of the total chemical oxygen demand and ammonia nitrogen emissions from traditional manufacturing industries respectively; industrial particulate matter, sulphur dioxide and nitrogen oxide emissions from air pollution accounted for 8.33%, 10.48% and 10.98% of the total sulphur dioxide, nitrogen oxide and industrial emissions in the traditional manufacturing sector accounted for 8.33%, 10.48% and 10.98% of the total emissions of

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particulate matter, respectively. Waste emissions from the textile industry have caused serious environmental pollution, hindering the transformation and upgrading of the textile industry into "green manufacturing" and becoming a bottleneck for the green development of the textile economy. Therefore, clarifying the relationship between economic growth and pollution emissions in the textile industry is conducive to exploring the path of green economic development in the textile industry and promoting the sustainable and healthy development of the textile industry.

Research in the literature on the relationship between the economy and pollution emissions has focused on three aspects: the measurement of pollution emissions, the measurement of the relationship between economic development and pollution emissions, and the selection of industries to be studied. First, there are mainly single-indicator methods [1] and comprehensive index methods [2, 3] on the measurement of pollution emissions. Kwong, Hongyan et al. (2020) directly used the emissions of a single pollutant to measure the intensity of pollution emissions [4], which is not comprehensive enough. Some scholars use the comprehensive index method to measure the pollution emission status by constructing an index system, such as Li Yuxia et al. (2022) used four dimensions of public green space area, road area industrial sulphur dioxide emissions and sewage discharge to construct an index system and measured the pollution emission intensity by assigning weights through the entropy weighting method [5]; Ban Glan and Liu Xiaohui (2021) [6] constructed an index system from gas pollution, water pollution, solid pollution and noise pollution Guo Yajun et al. (2015) proposed an improved "factor analysis" based on the comprehensive index method to assess the pollution emission intensity [7], but did not consider the different effects of various indicators and did not classify the pollution indicators. (2018) used this method to differentiate air pollution from other pollutants by using factor analysis, and then used the pull-down ranking method to assign weights to the index system to comprehensively measure the pollution emission intensity [8]. Second, the main measures of the relationship between economic growth and pollution emissions are the environmental Kuznets curve (EKC) [9], the decoupling model [10], the coupling coordination model [11] and the centre of gravity model [12]. Fan and Li (2022) and Kaufmann et al. (1998) have verified the environmental Kuznets curve between economic growth and environmental pollution and concluded that the relationship between the two is "inverted U-shaped" [13, 14]; Qi and Yawei (2018) used the decoupling model based on GDP and carbon dioxide data (2018) used a decoupling model to explore the relationship between carbon emissions and economic growth [15]; Pang, Jia-Xing and Chen, Xing-Peng (2017) used a coupled coordination model to study the spatial distribution pattern of economic and pollution emissions in Gansu Province [16]. The above studies were all conducted from the time dimension and did not analyze the relationship between the two from the spatial dimension, so some scholars used the centre of gravity model to study the spatial and temporal trajectories of the centre of gravity of the economy and the centre of gravity of pollution emissions [4] and the coupling dynamics, Liu Xian Zhao et al. (2017) [17] studied the evolution trend of the centre of gravity of carbon emission efficiency and the centre of gravity of economic development in Hunan Province based on the centre of gravity model, and other scholars used the coupled centre of gravity model to analyze the coupling between the centre of gravity dynamics [18]. Third, the selection of research industries, as different industries have different economic and pollution emission characteristics, scholars have studied the coal industry [19], the iron and steel industry [20] and the tourism industry [21] to reveal the interrelationship between economic growth and pollution emissions specific to each industry. Li Yanlin et al. (2021) used the Yulin coal industry as the research object [22] to assess the level of coupling and coordination between pollution and economy in the coal industry; Fan Fengyan et al. (2020) used the steel industry as the research object [23] to reveal the coupling and coordination state between economy and environment in the steel industry and put forward policy recommendations for the development of the steel industry; scholars have not only studied the heavy industry, but also the tourism industry scholars have not only studied the heavy industry, but also the tourism industry, exploring the level of development between the economy and the environment in the process of developing tourism [24].

In summary, the existing studies on the relationship between economic growth and pollution emissions, in terms of measuring pollution emissions, mainly through the comprehensive index method to measure the intensity of pollution emissions, but the entropy weighting method directly to the indicator system does not take into account the different effects of different types of pollution indicators, while the improved factor analysis based on the pull-off grade method can be a comprehensive consideration of the type of indicators, the use of factor analysis to distinguish by category before measuring the intensity of pollution emissions. The factor analysis can be used to differentiate between categories and then measure the intensity of pollution emissions. In the evaluation of the relationship between economic development and pollution emissions, most scholars analyse the relationship between pollution emissions and economic development through the time dimension, without considering the spatial interrelationship. In contrast, the centre of gravity model can describe the trajectory of economic and pollution centres of gravity from a spatial and temporal perspective, presenting the geographical relationship between the two in a latitudinal and longitudinal manner. In terms of the choice of industries to be studied, heavy industry is a more serious pollution problem, so there is more literature on existing studies revolving around heavy industry. Although the textile industry is a light industry, its pollution emissions are also more serious, and the issue of economic growth and pollution emissions in the textile industry also needs attention.

By drawing on the methods and ideas of existing studies, the main contributions of this paper are: first, to measure the intensity of pollution emissions from the textile industry by using the improved pull-off method based on factor analysis, which takes into account the seriousness of water pollution in the textile industry in comparison with other methods, and uses factor analysis to distinguish water pollution from other pollution indicators in the textile industry, so as to comprehensively measure the intensity of pollution emissions from the textile industry; second, to take the textile industry as the research object. The relationship between economic development and pollution emissions in the textile industry is studied. The existing literature on the economy and pollution mainly focuses on heavy industry, with less attention paid to the relationship between the economy and pollution in the textile industry; thirdly, micro-level data is chosen to characterise the textile industry by textile enterprises, which can accurately reflect the situation of the textile industry, as previous studies are mostly based on the macro-level, with less attention paid to micro-level studies. Thirdly, the use of micro-level data to characterise the textile industry can accurately reflect the situation of the textile industry.

2 Research Design

This paper takes the textile industry as the research object and selects micro data from 1998 to 2013 to study the textile industry, firstly, using the pull-out grade method based on factor analysis to measure the pollution emission intensity of textile enterprises; then using the gross industrial output value of textile enterprises to calculate the economic centre of gravity of the textile industry through the centre of gravity model, using the pollution emission intensity of textile enterprises to measure the centre of gravity of the textile industry through the centre of gravity model, analyzing the economic and The spatial and temporal trajectories of the textile industry's economic and pollution emission centres of gravity are analysed; the grey correlation method is then used to measure the correlation between the textile industry and the economic and pollution emission centres of gravity of sub-sectors in latitude and longitude; finally, the coupling of the textile industry's economic and pollution emission centres of gravity is evaluated from both static and dynamic perspectives using the centre of gravity coupling posture model. The methodology used for this process is as follows.

2.1 Research Methodology

2.1.1 Improved Open Grade Method Based on Factor Analysis

In this paper, we choose to measure the pollution emission behaviour of the textile industry by excluding the scale effect. the pollution emission per unit of output [25, 26]. This paper draws on the study of Ban Glan et al. (2018) [8] to measure the pollution emission intensity of textile enterprises using an improved pull-out gearing method based on factor analysis. Considering that water pollution is the most serious environmental problem of textile enterprises in China, firstly, water pollution (industrial wastewater, chemical oxygen demand) is treated differently from other pollution indicators (industrial waste gas, sulphur dioxide and smoke and dust) by using factor analysis to classify them, and then the pull-out ranking method is applied to assign weights to measure the pollution emission intensity of textile enterprises, and finally, the pollution emission intensity of textile enterprises is used to characterise the pollution emission behaviour of the textile industry. The specific calculation formula is.

$$p_{it} = \sum_{j=1}^{k} [(X_{itj}^{*} \times W_{itj}) \times \omega_{it}^{(j)}] \quad (1)$$

Of which, P indicates pollution emission intensity; j indicates a dummy law to distinguish between water and air pollution indicators in textile enterprises through factor analysis; k indicates the total number of dummy laws determined by factor analysis to distinguish between water and air pollution indicators in textile enterprises; X^{*} indicates the matrix formed by dividing the five pollutant indicators within a dummy criterion; W indicates the matrix of weights for each indicator within the virtual criteria determined by the longitudinal and cross-sectional slotting method; ω indicates the weight of each dummy criterion determined by the subjective assignment method; Subscript i and t indicates province and year.

2.1.2 Centre of Gravity Model

Textile industry economic centre of gravity or the centre of gravity of pollution emissions refers to China's textile industry economic growth or pollution emissions common point of action, its changes in time and latitude and longitude can indicate the textile industry economic centre of gravity or the centre of gravity of pollution emissions spatial and temporal migration trajectory. The expression of the centre of gravity of the textile industry's economy or pollution emissions is:

$$\overline{x_t} = \frac{\sum_{i=1}^{n} M_{it} \times x_{it}}{\sum_{i=1}^{n} M_{it}}, \quad \overline{y_t} = \frac{\sum_{i=1}^{n} M_{it} \times y_{it}}{\sum_{i=1}^{n} M_{it}} \quad (2)$$

Of which, $\overline{x}$ and $\overline{y}$ indicate the longitude and latitude of the economic centre of gravity or the centre of gravity of pollution emissions from the textile industry respectively; x and y indicate the longitude and latitude of the provincial capital city respectively; i indicates province, n indicates the total number of provinces; M indicates the gross industrial output or pollution emission intensity of the textile industry.

2.1.3 Grey Correlation Method

The grey correlation method is used to measure the size of the economic and pollution emission gravity warp and latitude correlation between the textile industry and the sub-sectors, and to determine how closely the textile industry is linked to each sub-sector, the expression for the grey correlation method is:

$$\xi_{0a}(t) = \frac{\min_a \min_t |r_0(t) - r_a(t)| + \xi \max_a \max_t |r_0(t) - r_a(t)|}{|r_0(t) - r_a(t)| + \xi \max_a \max_t |r_0(t) - r_a(t)|} \quad (3)$$

$$\gamma(r_0, r_a) = \frac{1}{b} \sum_t \xi_{0a}(t) \quad (4)$$

Of which, r_0 indicates the latitude and longitude of the economic centre of gravity of the textile industry or the centre of gravity of pollution emissions, r_a indicates the latitude and longitude of the economic centre of gravity or the centre of gravity of pollution emissions in the sub-sector, a indicates the number of sub-sectors; t indicates year, Total b years; ξ takes values from 0 to 1, the general value is 0.5; ξ_{0a} is the correlation coefficient between the textile industry and the sub-sector; γ indicates the degree of correlation between the textile industry and the sub-sectors.

2.1.4 Centre of Gravity Coupling Posture Model

(1) Spatial overlap

Spatial overlap refers to the spatial distance between the economic centre of gravity of the textile industry and the centre of gravity of pollution emissions, and is a static indicator. The smaller the value of spatial overlap, the closer the spatial distance between the two and the higher the coupling between the two centres of gravity indicated by the following formula:

$$D = k \times \sqrt{(x_{tE} - x_{tP})^2 + (y_{tE} - y_{tP})^2} \quad (5)$$

Of which, D indicates the spatial overlap between the economic centre of gravity of the textile industry and the centre of gravity of pollution emissions; k indicates the factor that converts the latitude and longitude coordinates of the Earth's surface into a plane distance and is a constant, takes a value of 111.11; x_{tE} 、 y_{tE} indicate the longitude and latitude of the economic centre of gravity of the textile industry in year of t; x_{tP} 、 y_{tP} indicate the longitude and latitude of the centre of gravity of textile pollution emissions in year of t.

(2) Consistency of change

Consistency of change is a dynamic indicator of the degree of consistency in the direction of change in the spatial and temporal trajectory of the economic centre of gravity and the centre of gravity of pollution emissions in the textile industry. The expressions are as follows:

$$C = \cos\theta = \frac{\Delta x_E \Delta x_P + \Delta y_E \Delta y_P}{\sqrt{(\Delta x_E{}^2 + \Delta y_E{}^2)(\Delta x_P{}^2 + \Delta y_P{}^2)}} \quad (6)$$

Of which, θ indicates the angle of the displacement vector of the centre of gravity for economic and environmental pollution, $\theta \in [0^\circ, 180^\circ]$; C indicates the sine of the angle, $C \in [-1,1]$, When the value is -1, it means that the economic centre of gravity and the centre of gravity of pollution emissions are moving in opposite directions, and when the value is 1, it means that the economic centre of gravity and the centre of gravity of pollution emissions are moving in exactly the same direction; Δx_E, Δy_E indicate the amount of interannual variation in the centre of gravity of the economy at longitude and latitude; Δx_P, Δy_P indicate the interannual variation in the centre of gravity of pollution emissions at longitude and latitude.

2.2 Data Sources and Processing

The enterprise-level data used in this paper comes from the China Industrial Enterprise Database and the China Industrial Enterprise Green Development Database. Firstly, the organisation and enterprise names in the two databases are matched, the first nine digits of the organisation code are matched again for those that are not matched, and finally the enterprise names are matched to supplement them. Finally, the data of the five indicators to be used in this paper were selected for the research of this paper.

After matching the database of Chinese industrial enterprises and the database of enterprise green development, the unbalanced panel data on economic and pollution emissions were obtained, and by drawing on the processing methods of Brandt et al. (2012) [27], Nie Huihua et al. (2012) [28] and Lin Ting (2021) [29], the data used in this paper were processed as follows: (1) excluding textile enterprises with negative values for gross industrial output value, industrial wastewater emissions, chemical oxygen demand emissions, industrial waste gas emissions, sulphur dioxide emissions and smoke and dust emissions of textile enterprises were negative, zero or missing; (2) excluding enterprises whose gross industrial output value of textile enterprises was missing, negative or did not comply with general accounting standards. The final unbalanced panel data for textile enterprises in 30 provinces (excluding Hong Kong, Macau, Taiwan and Tibet) from 1998 to 2013 were obtained.

According to the matching database of China Industrial Enterprise Database and China Industrial Enterprise Green Development Database, the textile industry is divided into cotton, chemical fibre textile and dyeing and finishing, wool textile and dyeing and finishing, hemp textile, silk textile and finishing, manufactured textile products and knitted and woven products and their products according to the three-digit code of the national economic industry classification standard GB/T 4754-2002 The six sub-sectors are cotton, chemical fibre textile and dyeing and finishing, woollen textile and dyeing and finishing, hemp textile, silk and silk textile and finishing, manufactured textile products, and knitted goods, woven goods and their products. As there are three national economic industry classifications for the period 1998-2013, the data for the years 1998-2002 and 2013, for which the GB/T 4754-2002 classification standard was not used, are presented in this paper for ease of categorisation by comparing the category names of the textile industry quartile codes in these years with those in the GB/T 4754-2002 classification standard. The category names of the textile quartile codes are grouped into the six sub-sectors of the textile industry in the GB/T 4754-2002 classification standard for the study of this paper.

3 The Spatio-temporal Trajectory of the Textile Industry and the Correlation with Sub-sectors

3.1 The Spatio-temporal Trajectory of the Economic Focus of the Textile Industry

3.1.1 Temporal and Spatial Trajectory of the Economic Focus of the Textile Industry

The spatial location, migration direction and migration distance of the overall economic centre of gravity of the textile industry are measured using the centre of gravity model, and the spatial and temporal trajectory of the economic centre of gravity of the textile industry from 1998 to 2013 is plotted in Figure 1.

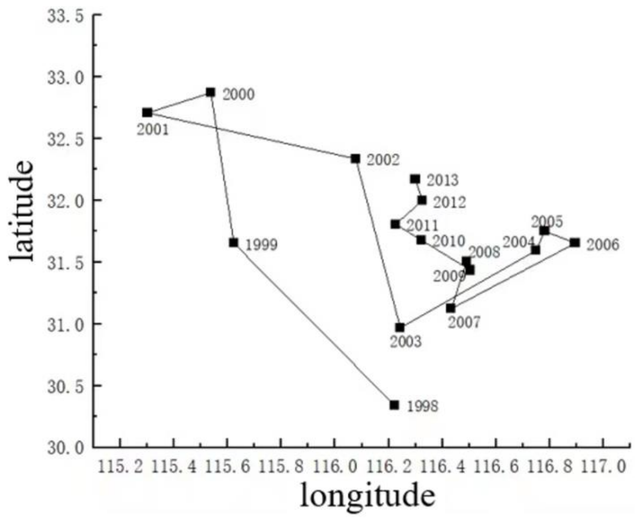

Figure 1 Temporal and spatial trajectory of the economic focus of the textile industry, 1998-2013

From 1998 to 2013, the economic centre of gravity of the textile industry was between 115.3021°E and 116.8943°E in longitude and between 30.3394°N and 32.8699°N in latitude, always located within the boundaries of Anhui Province. between 1998 and 2013, the economic centre of gravity of the textile industry moved five times in the northwest direction, two times in the southwest direction, four times in the southeast direction, and four times in the The centre of gravity of the textile industry shifted from 30.3394°N, 116.2227°E (Anqing City, Anhui Province) to 32.1688°N, 116.2986°E (Liuan City, Anhui Province) four times in the northeast direction. In the first phase, from 1998 to 2001, the centre of gravity of the textile industry moved to the northwest, from Anqing City, Anhui Province, to Fuyang City, Anhui Province; in the second phase, from 2001 to 2006, the centre of gravity of the textile industry continued to move to the southeast, from Fuyang City to Hefei City; in the third phase, from 2006 to 2013, the centre of gravity of the textile industry In the third stage, from 2006 to 2013, the economic centre of gravity of the textile industry shifted to the northwest, but remained stable in Liuan City. The latitude values of the centre of gravity of the textile industry moved northwards between 1998 and 2000, southwards between 2001 and 2006, and northwards again between 2006 and 2013. The longitudinal and latitudinal values of the economic centre of gravity follow the same evolutionary trend, shifting westwards, then eastwards and finally westwards again, using the years 2000 and 2006 as the boundary.

In the first phase, from 1998 to 2001, the economic centre of gravity of the textile industry as a whole moved in a north-westerly direction at a relatively rapid rate, with a total migration of 327.81 km and an average annual migration rate of 109.27 km. In the second phase 2001-2006, the economic centre of gravity of the textile industry as a whole moved in a southeasterly direction, with the economic centre of gravity of the textile industry moving more rapidly than in the first phase during 2001-2004, with a total migration of 337.91 km and an average annual migration speed of 112.64 km; the economic centre of gravity of the textile industry moved slowly during 2004-2006, with a total migration of 34.46 km and an average annual migration speed of 17.23 km. Between 2001 and 2006, the centre of gravity of the textile industry experienced rapid-slow fluctuations, with an average annual migration rate of 74.47 km and a total migration of 372.37 km. In the third phase, from 2006 to 2013, the economic centre of gravity of the textile industry moved in a north-westerly direction and the overall movement rate was in a stable phase, with an overall migration distance of 223.42 km and an average annual movement rate of 31.92 km.

3.1.2 Analysis of the Correlation Between the Textile Industry and the Economic Focus of the Sub-sectors

The centre of gravity model was used to measure the latitude and longitude of the economic centre of gravity of the six sub-sectors. The grey correlation method was then used to measure the correlation between the six sub-sectors and the economic centre of gravity of the textile industry in terms of longitude and latitude.

Based on the results of the grey correlation method, the grey correlation between the economic centre of gravity of the textile industry and the six sub-sectors in the period 1998-2013 was (0.8843, 0.7717, 0.6104, 0.5366, 0.5781, 0.8548). The cotton, chemical fibre textile and dyeing and finishing industries have the highest correlation with the economic centre of gravity of the textile industry in longitude with a value of 0.8843, indicating that the cotton, chemical fibre textile and dyeing and finishing industries have the strongest correlation with the economic centre of gravity of the textile industry in longitude, indicating that the economic centre of gravity of the cotton, chemical fibre and dyeing and finishing industries have the strongest influence on the economic centre of gravity of the textile industry in longitude. 1998-2013 The economic centre of gravity of the textile industry and the six The grey correlation between the economic centre of gravity of the textile industry and the six sub-sectors in latitude is (0.9105, 0.8330, 0.6785, 0.7775, 0.7697, 0.6342), and the highest correlation between the economic centre of gravity of the cotton, chemical fibre textile and dyeing finishing industry and the textile industry in latitude with a value of 0.9105, indicating that in latitude, the cotton, chemical fibre textile and dyeing finishing industry The strongest latitudinal correlation with the economic centre of gravity of the textile industry indicates that the economic centre of gravity of the cotton, chemical fibre textile and dyeing and finishing industries has the greatest influence on the economic centre of gravity of the textile industry in latitude. This means that the industrial output of the cotton, chemical fibre textile and dyeing and finishing industries has the greatest influence on the economic growth of the textile industry and is the main driver of economic growth in the textile industry.

3.2 Spatio-temporal Trajectory of the Focus of Pollution Emissions from the Textile Industry

3.2.1 Spatio-temporal Trajectories of the Focus of Pollution Emissions from the Textile Industry

The spatial location, migration direction and distance of the centre of gravity of pollution emissions from the textile industry were measured using the centre of gravity model, and the spatial and temporal trajectory of the centre of gravity of pollution emissions from the textile industry from 1998 to 2013 was plotted, as shown in Figure 2.

From 1998 to 2013, the centre of gravity of pollution emissions from the textile industry was between 108.2270○E and 113.4985○E in longitude and between 30.7318○N and 34.9239○N in latitude, migrating towards the central and western regions along Shanxi-Henan-Hubei-Shaanxi. During the period 1998-2013, the centre of gravity of textile pollution emissions shifted five times to the northwest, four times to the southwest, three times to the southeast and three times to the northeast. The first stage was from 1998 to 2001, when the centre of gravity of pollution emissions from the textile industry moved significantly southwards, between Shaanxi Province and Henan Province; the second stage was from 2001 to 2010, when the centre of gravity of pollution emissions from the textile industry moved irregularly, but always within Hubei Province; the third stage was from 2010 to 2013, when the centre of gravity of pollution emissions from the textile industry The third stage was from 2010 to 2013, when the centre of gravity of pollution emissions from the textile industry moved to the northwest, to Shaanxi Province.

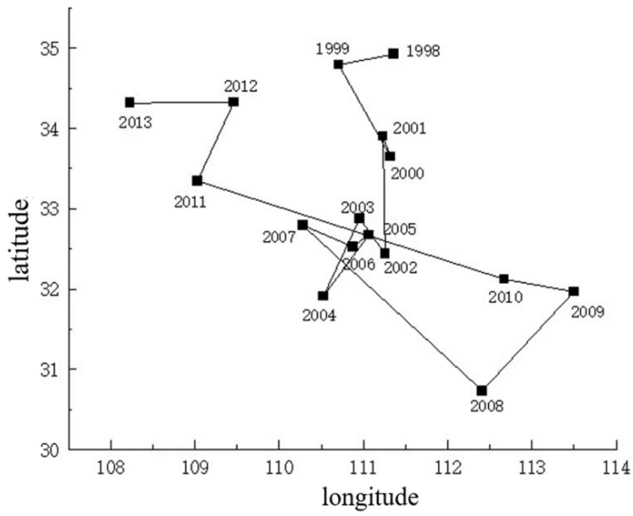

Figure 2 Spatial and temporal trajectory of the centre of gravity of pollution emissions from the textile industry, 1998-2013

In the first phase, from 1998 to 2001, the centre of gravity of the textile industry moved southwards with a steady rate of movement, with a total of 248.07 km, and an average annual migration rate of 82.69 km. In the second stage, from 2001 to 2010, the centre of gravity moved steadily between 2001 and 2007, with a total of 543.14 km and an average annual migration speed of 90.52 km; between 2007 and 2010, the centre of gravity moved rapidly, with a total of 605.18 km and an average annual migration speed of 201.73 km; in the second stage, the centre of gravity of pollution emissions moved steadily to rapidly, with a total of 1148.18 km and an average annual migration speed of 201.73 km. In the second stage, the centre of gravity of pollution emissions moved rapidly, with a total of 1,148.32 km, and the annual average speed of movement was 164.05 km, but the centre of gravity of pollution emissions in the second stage always moved within the Hubei provincial boundary. In the third stage, between 2010 and 2013, the centre of gravity of pollution emissions from the textile industry moved to the border of Shaanxi province, and the speed of movement peaked at 683 km, with an average annual movement of 227.67 km. Overall from 1998-2013 the centre of gravity of textile pollution emissions moved towards the central and western regions along the lines of Shanxi-Henan-Hubei-Shaanxi, due to the implementation of the strategy of shifting the centre of gravity of the textile industry to the west, resulting in the centre of gravity of pollution emissions moving towards the west.

3.2.2 Analysis of the Correlation Between the Textile Industry and the Focus of Pollution Emissions in the Sub-sectors

The centre of gravity model (2) was used to measure the latitude and longitude of the centre of gravity of pollution emissions in the six sub-sectors. The grey correlation method was then used to measure the correlation between the six sub-sectors and the textile industry in terms of the longitude and latitude of the centre of gravity of pollution emissions.

Based on the grey correlation method, the grey correlation between the centre of gravity of pollution emissions in the textile industry and the six sub-sectors from 1998 to 2013 was (0.7902, 0.7783, 0.6649, 0.7878, 0.5212 and 0.6963). The highest correlation between the cotton, chemical fibre textile and dyeing and finishing industries and the centre of gravity of pollution emissions from the textile industry was found in the longitude scale, with a value of 0.7902, indicating that the cotton, chemical fibre textile and dyeing and finishing industries have the strongest correlation with the centre of gravity of pollution emissions from the textile industry in the longitude scale, indicating that the centre of gravity of pollution emissions from the cotton, chemical fibre textile and dyeing and finishing industries has the strongest influence on the centre of gravity of total pollution emissions from the textile industry in the longitude scale. 1998-2013 The grey correlation between the centre of gravity of pollution emissions in the textile industry and the six sub-sectors in latitude from 1998 to 2013 is (0.7346, 0.7062, 0.6300, 0.4795, 0.7609, 0.6682), with the textile manufactured goods manufacturing industry having the highest correlation with the centre of gravity of pollution emissions in the textile industry in latitude, with a value of 0.7609, indicating that in latitude, the textile This indicates that the textile manufacturing industry has the strongest correlation with the centre of gravity of pollution emissions from the textile industry at latitude, indicating that the textile manufacturing industry has the strongest influence on the centre of gravity of pollution emissions from the textile industry at latitude. By looking at the latitude correlation values, we can see that the cotton, chemical fibre textile and dyeing finishing industries are second only to the textile manufactured goods manufacturing industry in terms of the latitude correlation with the centre of gravity of pollution in the textile industry, and their correlation is highest in terms of longitude, so the pollution emissions from the cotton, chemical fibre textile and dyeing finishing industries are also a factor in causing serious pollution in the textile industry.

4 The Coupling Dynamics of the Textile Economy and Pollution Emissions in the Centre of Gravity

In order to further analyse the coupling between the economic focus of the textile industry and the focus of pollution emissions, the spatial overlap and the shifting consistency index are used to analyse the coupling dynamics of the two from a static and dynamic perspective respectively.

4.1 Spatial Overlap

From a static perspective of spatial overlap, the spatial overlap of the centre of gravity of the textile economy and pollution emissions from 1998 to 2013 shows a "W" shaped trend. From 742.51 km in 1998 to 471.09 km in 2001, then rising to the highest point of 946.69 km in 2006, decreasing again to the lowest point of 339.03 km in 2009, and finally rising again to 928.03 km in 2013, the spatial distance between the centre of gravity of the textile industry economy and the centre of gravity of pollution emissions was the smallest in 2009, and the spatial overlap was the strongest. The spatial distance between the economic centre of gravity of the textile industry and the centre of gravity of pollution emissions is the smallest and the spatial overlap is the strongest. However, after 2009 the spatial distance between the two expanded rapidly and the spatial overlap became weaker and weaker, as shown in Figure 3. The reason for this is the implementation of the strategy of shifting the centre of gravity of the textile industry to the west. Taking into account the abundance of raw materials and the labour intensity in the central and western regions, the centre of gravity of the textile industry has gradually shifted from the southeast to the central and western regions. The ensuing pollution problem of the textile industry also shifted to the west, while the economic development of the textile industry in the southeast has long been dominant and the economic centre of gravity of the textile industry is relatively stable, leading to a deterioration in the coupling trend of the latter two centres of gravity.

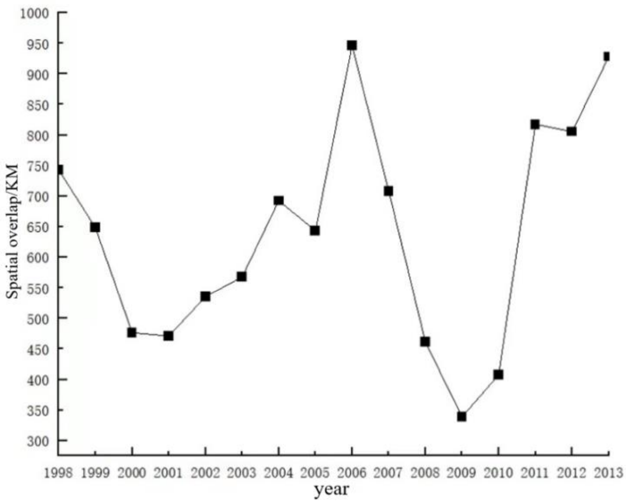

Figure 3 Spatial overlap of economic and pollution emission centres of gravity in the textile industry, 1998-2013

4.2 Consistency of Change

From the dynamic perspective of consistency of change, the consistency of change index of economic and pollution emission centres of the textile industry from 1998 to 2013 shows a multi-stage wave-like jump between positive and negative values, and there are several peaks and troughs in the process of fluctuation, which indicates that the economic centre of gravity and the pollution centre of gravity move in different directions. Specifically, the fluctuation consistency index of the two was greater than 0 in eight years and less than 0 in seven years; the average matching degree was 0.01, indicating a weak match between the two and a poor overall coupling between them. However, after 2009, the average matching degree was 0.42 and the consistency index of change increased significantly, as shown in Figure 4. The reason for this is that when the centre of gravity of the textile industry shifted to the west, the economic development of the textile industry in the southeast has long been dominant, resulting in the economic centre of gravity of the textile industry shifting to the west at a much slower rate than the centre of gravity of pollution emissions shifting to the west, so that there is an increasingly poor spatial overlap although the direction of change is consistent.

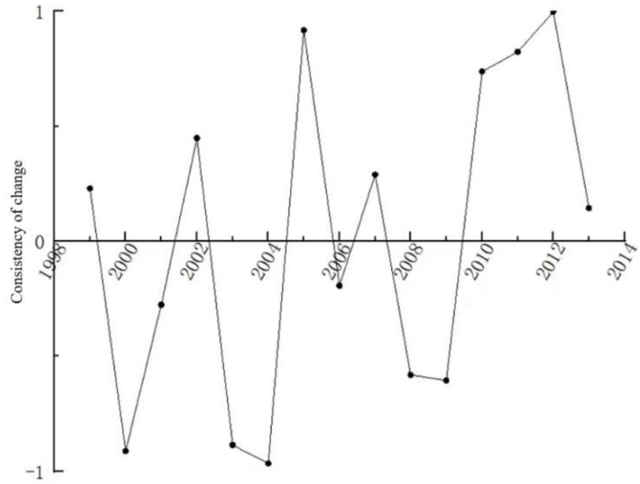

Figure 4 Trend of fluctuation of the consistency index of changes in the centre of gravity of the textile economy and pollution emissions, 1998-2013

5 Conclusions and Recommendations for Countermeasures

5.1 Conclusion

(1) the economic centre of gravity of the textile industry has been moving within Anhui Province from 1998 to 2013. The economic centre of gravity of the textile industry has the highest correlation with the economic centre of gravity of the cotton, chemical fibre textile and dyeing and finishing industries in terms of latitude and longitude, so the output value of the cotton, chemical fibre textile and dyeing and finishing industries has the greatest impact on the economic growth of the textile industry. (2) the spatial and temporal trajectory of the centre of gravity of pollution emissions in the textile industry from 1998 to 2013 passed through Shanxi Province - Henan Province - Hubei Province - Shaanxi Province, gradually shifting towards the central and western regions. The centre of gravity of pollution emissions from the textile industry has the highest

correlation with the centre of gravity of pollution emissions from the cotton, chemical fibre textile and dyeing and finishing industries in longitude, and the highest correlation with the textile manufacturing industry in latitude, followed by the cotton, chemical fibre textile and dyeing and finishing industries, so the pollution emissions from the cotton, chemical fibre textile and dyeing and finishing industries and the textile manufacturing industry are the main factors causing serious pollution in the textile industry. (3) the coupling trend between the textile industry economy and the centre of gravity of pollution emissions shows a "W" shape, in 2009 the centre of gravity of the two is the closest spatial distance, after that due to the textile industry centre of gravity in the central and western regions of the strategy, the centre of gravity of pollution emissions quickly moved to the central and western regions, and the southeast region textile industry economic development dominates, the centre of gravity of the textile industry economy to The economic development of the textile industry in the south-eastern region is dominant, and the economic centre of gravity of the textile industry is shifting to the central and western regions at a much slower rate than the centre of gravity of pollution emissions, which eventually leads to the deterioration of the coupling between the two.

5.2 Recommendations for Countermeasures

Industry level: Control pollution emissions from the cotton, chemical fibre textile and dyeing processing industries. In the cotton and chemical fibre textile process, especially the printing and dyeing process, we should try to reduce the pollution formed in the production process by introducing new technologies and materials from the southeast; we can also reduce the formation and emission of pollutants by upgrading environmental protection equipment and reprocessing the "three wastes" discharged from production.

Regional level: adjust measures to local conditions and rationally use the advantageous resources of each region. When undertaking the textile industry transfer in the southeast, the central and western regions should make rational use of the local superior resources, instead of simply consuming the region's own raw materials, labor and other superior resources for extensive production, ignore the pollution problem, and control the total amount of pollution emissions while achieving economic growth in the textile industry.

Government level: good policy support, improve social supervision system. To increase the policy to the textile industry, to encourage textile enterprises green technology and green equipment research and development and introduction, to provide financial support; at the same time the relevant departments should also improve the green assessment system, in the pursuit of economic growth at the same time, strict control of the total amount of pollutant emissions in the textile industry; improve environmental protection policies and supervision system, reasonable play of social supervision rights.

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