Performance Evaluation and Spatio-temporal heterogeneity analysis of green Technology Innovation in The Yangt River Economic Belt

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Abstract. Starting from defining the connotation of green technology innovation performance, the evaluation index of green innovation performance was constructed. The panel data of industrial enterprises in the Yangtze River Economic Belt from 2010 to 2018 were selected. Dea-sbm model and entropy weight method were used to evaluate and diagnose the green technology innovation performance in the Yangtze River Economic Belt. The results show that; Under time heterogeneity; (1) The performance level of green technology innovation in the Yangtze River Economic Belt and the three regions is generally low and shows periodic fluctuations; (2) The green technology innovation performance of downstream regions "Jiangsu, Zhejiang and Shanghai" is at the level of "high green efficiency and high innovation efficiency", while the middle and upstream regions are always at the level of "low green efficiency and low innovation efficiency"; Under spatial heterogeneity :(1) the green technology innovation performance level of the Yangtze river economic belt is significantly different; > in the downstream region, > in the midstream region, and > in the upstream region; (2) Only nearly 30% of the provinces and cities are in the "high green efficiency and high innovation efficiency", while the rest of the provinces and cities are in the "low green efficiency and low innovation efficiency".

Keywords: Green technology innovation; Yangtze River Economic Belt; Innovation performance; Spatiotemporal heterogeneity.

1. Introduction
At present, China's economy has changed from the stage of rapid growth to the stage of high-quality development. While the traditional extensive economic growth mode has made great contributions to the rapid development of China's economy, it has also brought a lot of ecological problems. According to the Opinions on Comprehensively Strengthening Ecological Environmental Protection and Resolutely Fighting the Tough Battle for Pollution Prevention and Control, the contradiction between social development and ecological environmental protection is still prominent today. Various environmental problems are interwoven, and problems such as heavy pollution weather, black and smelly water bodies and garbage siege occur from time to time, which have become the bottleneck of sustainable development [1]. With the concept of "ecological civilization", "two-oriented society" and "beautiful China", how to realize the coordinated development of economy, energy and environment is
the pressing task of socialist modernization at the present stage. The five development concepts of "innovation, coordination, green development, openness and sharing" have pointed out the direction of China's economic development. Innovation leads green development is the only way for high-quality economic development, and green innovation arises at the historic moment.

2. Literature Review
Green technology innovation is also known as "ecological technology innovation, environmental technology innovation, circular sustainable technology innovation", etc. The research on green technology innovation started late and the development period is short, so the concept of green technology innovation is not unified. Different scholars in the field of research based on their own research tentative definition of its concept: the regional level, focus on regional economic development, think green technology innovation is through technical innovation and institutional arrangement, with the minimum energy consumption and environmental pollution, to achieve maximum output, at the same time to realize the sustainable growth of economy innovation [1]; At the industrial level, from the perspective of promoting industrial vitality, green technology innovation is to stimulate industrial vitality, improve industrial efficiency, reduce energy consumption, and achieve green output innovation[2, 3]. At the micro level of enterprises, from the perspective of product production process, green technology innovation is the process innovation to reduce resource consumption and pollution emission in the production process of enterprises [4].

Based on the above research viewpoints, from the perspective of environment and technology, this paper holds that green technology innovation is an innovation that balances the improvement of technological innovation efficiency with the reduction of resource consumption and environmental pollution. Namely, green technology innovation consists of two parts: green technology and technological innovation.

Innovation performance is the best indicator to measure innovation ability, and green technology innovation performance is the evaluation of the efficiency and effect of enterprises' green innovation activities. Compared with previous technological innovation performance which only considers economic output, green technological innovation performance increases the impact of personnel, resources, funds and other inputs, pollution emissions and other undesired outputs on technological innovation performance. But in previous research, the existing research on single consider green technology innovation performance of green technology or technology innovation efficiency, there is no clearly defined the connotation of the green technology innovation performance, draw lessons from scholars Alegre [5], this paper argues that green technology innovation performance covers the green technology and the two dimensions of technological innovation, is a green technology and technological innovation efficiency of integration, the specific time period under the innovation resource constraints and environmental impact, green innovation investment of environmental benefits and between the input and output of technology innovation efficiency. In view of this, green technology innovation performance is divided into four levels according to the combination of green technology efficiency and technological innovation efficiency, as shown.

In terms of the construction of evaluation index system, some scholars, based on the perspective of output, such as Garcia-Granero [6], believe that green innovation performance evaluation index can be divided into four types: product, process, organization and marketing. Rizos [7] et al. constructed an evaluation index system from the aspects of direct performance level, indirect performance level, knowledge output level, ecological performance and economic performance. Tseng et al. [8] believe that the performance evaluation of green innovation should cover four aspects: management innovation, process innovation, product innovation and technological innovation.

From the perspective of research objects, relevant academic researches on evaluating technological innovation performance generally focus on three levels: regional, industrial and enterprise. Regional level, Wang Caiming [9], DEA method to measure the 2005-2015 China regional innovation efficiency; green Ren Yao[10], percussion and other cattle industry in Shanxi Province based on DEA - RAM model green innovation efficiency is evaluated. The industry level, high XiaoWenHe Lin list [11] with
SFA model estimates from 2000-2009 China's 36 industry technology innovation efficiency, found that China's industry technology innovation average efficiency is not high. And market-oriented, technology innovation efficiency is significantly lower than the non-market oriented technology innovation efficiency value. De-cheng Fan, Du Mingyue [12] were studied with StoNED model (2018) technological innovation efficiency of China's high-end equipment manufacturing industry, shows a low efficiency of technology research and development phase is the main bottleneck of the overall effectiveness of the high-end equipment manufacturing industry. The enterprise level, XiaoRenQiao [13] (2015) from the perspective of value chain analysis, such as the enterprise technology innovation efficiency of the transformation of technology development and achievements of the second stage, he introduced the innovative Shared investment associative two-phase DEA method, It is concluded that the original innovation input can have a direct impact on the economic performance after the final transformation.

3. Selection Of Green Technology Innovation Index System For The Yangtze River Economic Belt

3.1. Evaluation dimension and evaluation index system

Establishing a scientific and feasible evaluation index system is the key to regional green innovation performance. Many scholars at home and abroad have studied the evaluation index system of green innovation performance, but the selection of these indexes is too much and relatively repeated. Based on the existing statistical indicators and the indicator system of authoritative journals such as China Science and Technology Evaluation, combined with the connotation definition of green innovation performance, this study studied the regional green innovation performance from the two dimensions of green innovation input and green innovation output.

Among them, green technology innovation input from the three aspects of human resources, capital, energy five secondary indicators, green innovation output from the economic benefits and environmental benefits five secondary indicators. Among them, the input indicator personnel input adopts the index of "r&d personnel equivalent to full time equivalent". Capital investment is subject to the two indexes of "internal expenditure on R&D" and "expenditure on new product development", and energy input is subject to the index of "total industrial energy consumption". For economic benefit, the two indicators are "number of effective invention patents" and "sales revenue of new products"; for environmental benefit, the three indicators are "industrial wastewater discharge", "industrial waste gas discharge" and "industrial solid waste discharge".

The calibre of China's statistical yearbook has been changed many times. In order to ensure the continuity of data, this data is taken from the panel data of all provinces and cities from 2008 to 2018. Considering the time lag of research and development, the lag period is taken as one year. The data used are from China Statistical Yearbook, China Science and Technology Statistical Yearbook and statistical yearbooks of provinces and cities.

Input-output factors should be determined when measuring the green technology innovation performance of the Yangtze River Economic Belt. In this paper, 11 provinces and cities of the Yangtze River Economic Belt are selected as the decision-making units, and the input-output indexes are shown in the Table 1.
Table 1. Performance evaluation index system of green Technology Innovation

| Level indicators | Target classification | The secondary indicators | The data source |
|------------------|-----------------------|--------------------------|---------------|
| Investment in green technology innovation | Human input | The r&d staff is full time equivalent | China Science and Technology Statistical Yearbook |
| Capital investment | Internal expenditure of R&D funds | Capital investment | China Science and Technology Statistical Yearbook |
| | New product development funds | Capital investment | China Science and Technology Statistical Yearbook |
| The energy input | Total industrial energy consumption | China Statistical Yearbook |
| Green technology innovation output | Economic benefits | Number of valid invention patents | China Science and Technology Statistical Yearbook |
| | New product sales revenue | China Science and Technology Statistical Yearbook |
| | Industrial added value | China Statistical Yearbook |
| Environmental benefits | Industrial wastewater discharge | Statistical yearbook of provinces and cities |
| | Industrial exhaust emission | Statistical yearbook of provinces and cities |
| | Industrial solid waste discharge | Statistical yearbook of provinces and cities |

4. Measurement Of Green Technology Innovation Performance In The Yangtze River Economic Belt

4.1. Research models and methods

a. SBM model

DEA is a relative effectiveness evaluation method based on input-output data. Using the observed sample data, DEA has significant advantages in evaluating the relative effectiveness among the same type of decision-making units with multiple inputs and multiple outputs. Because the traditional DEA model (such as CCR and BCC) is based on linear segmentation and radial theory to measure efficiency, it does not consider the problem of input-output relaxation, nor does it consider the existence of undesired output. To make up for the defects, the Tone is proposed considering the expected output of DEA - SBM models, the slack variable into the objective function, think in terms of input and output of two inefficiency situation, very good solution to the input and output slack sexual problems, and contains the expected output efficiency evaluation, and is widely applied in ecology and environment, etc. The specific model is expressed as follows:

Suppose there are N decision making units, m inputs, element \( x \in R^m \), define \( x \in (x_1, x_2, ..., X_n) \in R^m \) and \( x_i > 0 \); S types of output, where \( s_1 \) expected output (element \( y^g_i \in R^s1 \)) and \( s_2 \) unexpected output (element \( y^b_i \in R^s2 \)) are defined as:

\[
Y^g = (y^{g_1}, y^{g_2}, ..., y^{g_n}) \in R^{S_1 \times n}
\]
\[
Y^b = (y^{b_1}, y^{b_2}, ..., y^{b_n}) \in R^{S_2 \times n}
\]

And \( y^g_i \geq 0, y^b_i > 0 \), then the dea-sbm model can be expressed as:
\[ p^* = \min p = \min \left\{ \frac{1}{m} - \frac{1}{x_0} \sum_{i=1}^{m} \frac{s_i^g}{x_i} \right\} \]

1 + \frac{1}{s_1 + s_2} \left\{ \sum_{i=1}^{m} \frac{s_i^g}{y_i^g} + \sum_{i=1}^{m} \frac{s_i^b}{y_i^b} \right\}

s.t. \ x_0 = X - s^- \\
\ y_i^g = Y + s^g - s^b \\
\ y_i^b = Y - s^b \\
\ \lambda \geq 0, s^- \geq 0, s^g \geq 0, s^b \geq 0

\[ S^- , s^g \text{ and } S^b \text{ are the relaxation variables of input, expected output and unexpected output respectively. The objective function strictly subtracts the variables } s^- , s^g, s^b, \text{ and the value of the objective function } p^* \in [0, 1]. \text{ When } p^* = 1, S^- , s^g \text{ and } S^b \text{ are all 0, indicating that the DMU is valid; When } P^* < 1, \text{ it means that the DECISION-MAKING unit is invalid, and the efficiency should be improved by increasing expected output, reducing input or unexpected output.} \]

4.2. Entropy weight method

Several output indexes are selected to evaluate the output benefit of green innovation. In the quantitative analysis of multiple indicators, different indicators may have different degrees of influence on the evaluation results, so the weight of each output indicator should be given accordingly. Generally speaking, index weights can be divided into subjective and objective. Considering that the evaluation of green innovation output benefits is mainly based on objective indexes and the characteristics of multiple indexes, this paper selects entropy weight method to assign weights to each output index. The so-called entropy weight method is a mathematical method to determine the weight of each index according to the amount of information provided by each index, synthesize each index and calculate a comprehensive index. Among them, the smaller the entropy value is, the greater the information provided by the index is, and the higher the index weight is. The specific calculation steps are as follows:

1. Calculate the characteristic proportion \( p_{ij} \) of the \( i \)th evaluation object under the \( J \)th index of the object to be evaluated:

\[ p_{ij} = \frac{v_{ij}}{\sum_{i=1}^{m} v_{ij}} \]

Since \( 0 \leq v_{ij} \leq 1, 0 \leq v_{ij} \leq 1 \)

2. The entropy value of the \( J \)th index was calculated by using the measured characteristic proportion of the index \( e_{ij} \):

\[ e_{ij} = \frac{1}{m} \sum_{i=1}^{m} p_{ij} \ln p_{ij} \]

When \( p_{ij} = 0, p_{ij} = 0, p_{ij} \ln p_{ij} = 0 \).

3. Calculate the entropy weight of the \( J \)th index \( w_{ij} \):

\[ w_{ij} = \frac{1-e_{ij}}{m - \sum_{j=1}^{m} e_{ij}} \]

4. Determine the comprehensive score of each evaluation object \( z_i \):

\[ z_i = \sum_{j=1}^{n} w_i v_{ij} \]
4.3. Data sources and processing
This article research scope including 11 provinces and regions of the Yangtze river economic zone, the research object of industrial enterprises, the time span is 2008-2018, both comparability, availability, and continuity of the sample data, all data derived from the corresponding to the year of China statistical yearbook, "China statistical yearbook of science and technology, industrial enterprise activities of science and technology statistical yearbook, local statistical yearbook and statistical bulletin, etc.

4.4. Calculation results
In this study, deA-Solve: Professional Version 5.0 software was used to calculate the green technology conversion efficiency of the Yangtze River Economic Belt, and the improved entropy weight method was used to comprehensively score the green technology conversion efficiency of the Yangtze River Economic Belt. The results are shown in Table 2.

| Green technology innovation performance | 2010 | 2011 | 2012 | 2013 | 2014 |
|----------------------------------------|------|------|------|------|------|
| Shanghai                               |      |      |      |      |      |
| jiangsu                                | 0.275| 1    | 0.186| 0.356| 0.15 | 0.316| 0.243| 0.558| 0.266| 0.644 |
| zhejiang                               | 0.188| 1    | 0.261| 1    | 0.679| 1    | 0.304| 1    | 0.324| 1    |
| Anhui                                  | 0.126| 0.355| 0.233| 0.167| 0.178| 0.467| 0.196| 0.707| 0.187| 0.7  |
| jiangxi                                | 0.115| 0.23 | 0.072| 0.189| 0.079| 0.209| 0.094| 0.243| 0.101| 0.237|
| Hubei                                  | 0.039| 0.192| 0.045| 0.161| 0.049| 0.174| 0.059| 0.266| 0.059| 0.23  |
| Hunan                                  | 0.082| 0.302| 0.091| 0.235| 0.096| 0.274| 0.111| 0.367| 0.112| 0.339|
| Chongqing                              | 0.064| 0.269| 0.076| 0.194| 0.082| 0.231| 0.097| 0.327| 0.101| 0.251|
| Sichuan                                | 0.063| 0.208| 0.088| 0.261| 0.087| 0.285| 0.091| 0.404| 0.097| 0.337|
| Yunnan                                 | 0.052| 0.198| 0.076| 0.272| 0.072| 0.285| 0.086| 0.379| 0.092| 0.289|
| Guizhou                                | 0.066| 0.495| 0.068| 0.383| 0.058| 0.364| 0.057| 0.348| 0.053| 0.279|
| The mean                               | 0.041| 0.242| 0.038| 0.18  | 0.044| 0.222| 0.05 | 0.278| 0.052| 0.231|
| Upstream of the mean                   |      |      |      |      |      |      |      |      |      |      |
| Middle mean                            | 0.128| 0.408| 0.111| 0.350| 0.143| 0.348| 0.126| 0.443| 0.131| 0.412|
| Downstream of the mean                 | 0.056| 0.286| 0.068| 0.274| 0.065| 0.289| 0.071| 0.352| 0.074| 0.284|
|                                        | 0.062| 0.254| 0.071| 0.197| 0.076| 0.226| 0.089| 0.320| 0.091| 0.273|
|                                        | 0.251| 0.646| 0.186| 0.541| 0.272| 0.498| 0.209| 0.627| 0.220| 0.645|
**Table 3.** Performance evaluation results of green technology innovation in the Yangtze River Economic Belt

| Green technology innovation performance | 2015    | 2016    | 2017    | 2018    | The mean |
|----------------------------------------|---------|---------|---------|---------|----------|
| Shanghai                               | Gree n  | innovatio n | Gree n  | innovatio n | Gree n  | innovatio n | Gree n  | innovatio n | Gree n  | innovatio n | Gree n  | innovatio n |
| Jiangsu                                | 0.300   | 0.398   | 0.315   | 0.555   | 0.330   | 0.611   | 0.389   | 0.723   | 0.306   | 0.573     |
| Zhejiang                               | 0.653   | 1.000   | 0.578   | 1.000   | 0.612   | 1.000   | 0.666   | 1.000   | 0.474   | 1.000     |
| Anhui                                  | 0.541   | 1.000   | 0.332   | 1.000   | 0.357   | 0.912   | 0.278   | 0.876   | 0.269   | 0.737     |
| Jiangxi                                | 0.102   | 0.191   | 0.098   | 0.236   | 0.100   | 0.312   | 0.103   | 0.334   | 0.096   | 0.242     |
| Hubei                                  | 0.054   | 0.180   | 0.050   | 0.254   | 0.052   | 0.238   | 0.061   | 0.259   | 0.052   | 0.217     |
| Hunan                                  | 0.118   | 0.313   | 0.111   | 0.355   | 0.118   | 0.378   | 0.121   | 0.363   | 0.107   | 0.325     |
| Chongqing                              | 0.102   | 0.182   | 0.100   | 0.311   | 0.103   | 0.286   | 0.108   | 0.265   | 0.093   | 0.257     |
| Sichuan                                | 0.092   | 0.279   | 0.090   | 0.355   | 0.101   | 0.298   | 0.098   | 0.304   | 0.090   | 0.303     |
| Yunnan                                 | 0.092   | 0.263   | 0.093   | 0.317   | 0.100   | 0.289   | 0.096   | 0.308   | 0.084   | 0.289     |
| Guizhou                                | 0.053   | 0.262   | 0.050   | 0.287   | 0.052   | 0.273   | 0.058   | 0.296   | 0.057   | 0.332     |
| The mean                               | 0.047   | 0.179   | 0.050   | 0.222   | 0.049   | 0.198   | 0.051   | 0.234   | 0.047   | 0.221     |
| Upstream of the mean                   | 0.196   | 0.386   | 0.170   | 0.445   | 0.179   | 0.436   | 0.184   | 0.451   | 0.152   | 0.409     |
| Middle mean                            | 0.071   | 0.246   | 0.071   | 0.295   | 0.076   | 0.265   | 0.076   | 0.286   | 0.070   | 0.286     |
| Downstream of the mean                 | 0.091   | 0.225   | 0.087   | 0.307   | 0.091   | 0.301   | 0.097   | 0.296   | 0.084   | 0.267     |
|                                       | 0.399   | 0.647   | 0.331   | 0.698   | 0.350   | 0.709   | 0.359   | 0.733   | 0.286   | 0.638     |

Level, at the same time, the space for further analysis of the differences of regional green technology innovation performance, this paper will be divided into the Yangtze river economic belt upstream area, middle area and lower reaches area, green technology will examine period average efficiency and the technological innovation efficiency of the Yangtze river economic belt as a benchmark, the definition is higher than the mean of the Yangtze river economic belt is a "high level", instead of "low level", and on the basis of 11 provinces and cities in the Yangtze river economic belt press the green technology innovation efficiency levels classified statistics, the results are shown in table 4.

**Table 4.** Distribution of green technology innovation performance levels in the Yangtze River Economic Belt

| Year | High green efficiency high innovation efficiency | High green efficiency low innovation efficiency | Low green efficiency high innovation efficiency | Low green efficiency Low innovation efficiency |
|------|--------------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| 2010 | Shanghai, Jiangsu                                | Zhejiang, Anhui                               | guizhou                                       | Jiangxi, Hunan, Hubei, Chongqing, Sichuan, Yunnan |
| 2014 | Shanghai, Jiangsu, Zhejiang                      | /                                              | /                                             | Anhui, Guizhou, Jiangxi, Hunan, Hubei, Chongqing, Sichuan, Yunnan |
| 2018 | Shanghai, Jiangsu, Zhejiang                      | /                                              | /                                             | Anhui, Guizhou, Jiangxi, Hunan, Hubei, Chongqing, Sichuan, Yunnan |
5. Spatio-Temporal Heterogeneity Analysis Of Green Technology Innovation Performance In The Yangtze River Economic Belt

5.1. Performance analysis based on time heterogeneity

See Figure 1 for the mean values of the Yangtze River Economic Belt as a whole and the upper, middle and lower reaches. It can be seen that the trend of the Yangtze River Economic Belt as a whole is basically the same as that of the upper, middle and lower reaches, showing cyclical fluctuations and all at a low level. The green innovation performance of the lower reaches of the Yangtze River Economic Belt is higher than the population average, while that of the upper and middle reaches is lower than the population average.

The level of green innovation performance shows a trend of polarization among regions. Selecting the first and last years, 2008, 2018 and the middle years, 2013 as the representative years (Figure 2), it is concluded that the green technology innovation performance of the Yangtze River Economic Belt in 2013 increased by 18.4% compared with that of 2008, among which the upper, middle and lower reaches increased by 15.8%, 20.4% and 18.7% respectively. The green technology innovation performance of the Yangtze River Economic Belt will grow by 22.5% in 2018 compared with 2013, with the upper, middle and lower reaches growing by 22.4%, 32.1% and 18.6%, respectively. The reasons are as follows: the downstream region has strong economic foundation, developed technological level, good innovation environment and superior green innovation development conditions, but the coordination between resources, technology and environment is not optimistic. In the middle reaches, resource endowment advantages and national policies are prominent. Meanwhile, it has a good industrial foundation and relatively large investment in innovation, so the innovation performance level is significantly improved. Due to good resource conditions, the upstream region is limited by slow industrial development and lack of scientific and technological human resources and advanced technologies, which leads to insufficient vitality for green development and slow improvement of performance level.

From table 2, 2010, there are two provinces in the "high green, high innovation", two provinces in the high and low green innovation, only in guizhou in the "low green, innovation", the rest of the six provinces are "low green, innovation", and in 2014 and 2018, the three provinces and cities in a state of
"high green, high innovation", only the Zhejiang "high green, low technology" become "high green, high innovation", the rest of the provinces and cities are double low status.

5.2. Performance analysis based on spatial heterogeneity

According to the average value of the green technology innovation performance of the provinces and cities of the Yangtze River Economic Belt, the spatial distribution of the green technology innovation performance of the Yangtze River Economic Belt was drawn. By Figure 3, the Yangtze river economic belt of green technology innovation performance level difference is apparent, "high green, high technology" there are three levels of provinces and cities, accounting for 27% of the Yangtze river economic belt, located in the downstream area of the Yangtze river economic belt, all the rest of the life and death for "low green, low technology", occupy 73% of the overall proportion of the Yangtze river economic belt.
Figure 3. Spatial distribution of green technology innovation performance in the Yangtze River Economic Belt

From the perspective of the three regions in the upper, middle and lower reaches, the green technology innovation performance level in the lower reaches is significantly higher than that in the upper and middle reaches, while the difference between the upper and middle reaches is small. The performance level of green technology innovation is closely related to the current situation of regional development. The economic foundation, industrial system, scientific and technological research and development, and management philosophy of downstream regions are all in the leading level of the whole region or even the whole country. They are the regions with the strongest economy and the strongest environmental protection consciousness in China, and they have obvious advantages in green technology innovation and development. The economic development in the upper and middle reaches is mainly in industries with high energy consumption and high pollution, lacking of resources for green innovation and the foundation for green innovation in the region. The development mode and the degree of resource allocation that depend on resource input make it impossible for a large amount of innovation resource input to obtain green output, so the innovation performance of green technology is mostly at the level of "low green and low technology"

6. Conclusions And Suggestions

6.1. Research Conclusion
This study defines the connotation of green technology innovation performance, constructs the evaluation index system of green technology innovation, selects the panel data of industrial enterprises in the Yangtze River Economic Belt from 2010 to 2018, evaluates the green technology innovation performance in the Yangtze River Economic Belt and analyzes the spatiotemporal heterogeneity based on THE DEA-SBM model and the improved entropy weight method. The main conclusions are as follows:

(1) Under time heterogeneity, the overall green technology innovation in the Yangtze River Economic Belt from 2010 to 2018 is low and shows cyclical fluctuation, but it is increasing year by year; Number of provinces and cities in different green technology innovation performance level small fluctuations, high green, high innovation level of provinces and cities by 2010, 2 to 3, 2018 in zhejiang
province has been added, but at the same time, the low green, innovation from six to eight, the provinces and cities in anhui province and guizhou province respectively by the "high and low green innovation" "low green and high technology" into "low green, innovation", indicates that the Yangtze river delta green technology innovation performance development more slowly and is very uneven.

(2) Under time heterogeneity: the middle and lower reaches of the Yangtze River Economic belt and the green technology innovation performance levels of various provinces and cities are significantly different; The performance level of green technology innovation in the region shows a trend of polarization. > in the downstream region, > in the midstream region, and > in the upstream region. There are 3 "high green and high innovation" provinces and cities, accounting for 27% of the whole region, and they are all concentrated in the downstream region. There are 9 "low green and low innovation" provinces and cities, accounting for 73% of the whole region. All the provinces and cities in the upstream region and downstream region are at the same level.

6.2. Policy Suggestions
(1) Policies should improve relevant policy systems to create a favorable environment for green technology innovation. Local governments should, from a macro perspective, promote regional green innovation policies in terms of financial support, industrial coordination, talent introduction and other aspects, promote the deep integration of green development and innovation-driven strategy, realize the rational development and utilization of resources and energy, and promote the sustainable and healthy development of the region.

(2) Different regions need to develop differentiation strategies in line with their own conditions. Considering the heterogeneity of regional development, different green innovation policies should be established to guide the coordinated development of regional scientific and technological innovation and ecological environment. At the same time, each region should strengthen communication and formulate appropriate policies from the perspective of regional overall coordination. The eastern region has given full play to its advantages in science and technology and geographical location, encouraged independent innovation, and promoted continuous improvement of green innovation performance by taking into account both economic growth and environmental improvement. The central and western regions should make full use of the advantages of backward technology and abundant resources, and increase investment in green innovation and ecological protection.

(3) Actively opening up to the outside world and improving the performance of regional green technology innovation. The Yangtze River Economic Belt needs to actively communicate with other regions in China to promote regional green technology innovation. The lower reaches of the Yangtze River Economic Belt should take the lead in introducing and learning foreign advanced green innovation technologies, improve their own technology market environment, and realize the market value transformation of green innovation achievements. Meanwhile, the central and western regions should strengthen technological exchange and interaction with the eastern regions, so as to promote the free flow and efficient allocation of resource elements among different regions. In this way, the green innovation activities in the Yangtze River Economic Belt are promoted and applied efficiently, and further promote the transformation of regional economy to the development mode driven by energy conservation, environmental protection and green innovation.

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