

Study on the Efficiency Assessment of Green Economy Development and Carbon Emission Reduction Paths in the Yangtze River Delta Region under the "Double Carbon" Target

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Abstract

In the context of upgrading the "double carbon" target to a long-term national strategy, the development of a green economy is an inevitable trend for high-quality social development. As the Yangtze River Delta occupies an important position in China's economic and ecological development, assessing the efficiency of green economy development and optimizing carbon emission pathways in this region can not only promote the development of the region but also serve as a model to promote the high-quality economic development and ecological civilization construction of the whole country. Based on the above background, this project takes the green economy of each prefecture-level city in the Yangtze River Delta region as the research object takes the relationship between carbon emissions and economic growth, the assessment of green economy development efficiency and carbon emission management as the research perspective, relies on theories of sustainable development, low-carbon economy, and externality, and draws on the practice of green economy development in foreign countries, to achieve the emission reduction commitments set by the Chinese government, mitigate global climate change, and achieve high-quality economic development and the 2035 vision. The study will provide reasonable and efficient policy recommendations for achieving the Chinese government's stated commitments to reduce emissions, mitigate global climate change, and achieve high-quality economic development and the 2035 vision.

Keywords

Green Economic Development; Yangtze River Delta; Impact Factors; Measurement.

1. Background of the Study

1.1. International Background

The concept of "green economy" was first proposed by the British environmental economist Pearce, who published his "Blueprint for a Green Economy" in 1989, in which he pointed out that the balance sheet of national economic development should include costs that are ecologically and environmentally harmful and detrimental to resource depletion [1]. The period 1970-2010 was dominated by the global brown economy, which saw rapid economic growth and the accumulation of vast material wealth, but this was accompanied by a series of problems such as the decay of resources and the environment and the fragmentation of society. The idea of a "green economy" is based on dissatisfaction with the economic model of the past 40 years. In addition, the first decade of the new millennium was marked by several rises, notably the ecological crisis and the burnout caused by market failures, which led to the enrichment of the idea with the ultimate aim of a green approach to sustainable development[2]. In 2012, the Rio+20 United Nations Conference on Sustainable Development took the green economy to a new level, advocating a new concept of green economy, a new economic model that places a high priority on the sustainable development of natural capital and points out the role of natural capital in driving productivity growth [3] which would greatly

facilitate the development of a green economy in the country. During this time, developed countries and regions such as the US, UK, Germany, Japan, and Korea have introduced a series of policies to support the development of a green economy. The Green Living Expo and Green Technology and Green Living Summit were held in Suining, Sichuan, China in 2017, with the theme of "Green Leads Fashion, Technology Changes Life", pushing green development towards the new goal of "Green Living". This has greatly enriched the concept of a "green economy". From these developments, the development of the times has led to the enrichment of the connotation of the green economy, which is a new requirement and challenge to the current economic development model of the world, and has become a global development trendsetter.

1.2. Domestic Background

Since the reform and opening up, although China's economic volume has been rising and has long since leaped to become the world's second-largest economy, and GDP has increased hundreds of times, it has been accompanied by a series of economic, social development and ecological and environmental problems, such as low economic efficiency, ecological imbalance, and unbalanced development. The contrast between economic volume and economic quality and efficiency as well as with other developed countries shows that China's development cannot be stopped. How China can develop its economy while living in better harmony with nature and how the fruits of development can better benefit the people, the introduction of the green economy concept has undoubtedly pointed the way for China's development version 3.0 and livelihood enhancement (2012-2050), and the world's green economy development history. The world's history of green economic development has also blazed the trail for China's green transformation of its economic and social development. High-quality green development is efficiency-oriented development, which enhances the efficiency of the economy and the ecosystem within the ecosystem's carrying capacity and promotes the harmonious development of the economy, society, and the environment. In recent years, China has strived to achieve steady economic growth and quality improvement, prioritized resource conservation and environmental protection, and committed to improving people's livelihoods and well-being; economic growth is going through a painful period of transition.

1.3. Regional Background

The Yangtze River Delta, with its dynamic economic development, high degree of openness, and strong innovation capacity, is one of China's most promising urban agglomerations, located in the alluvial plain before the Yangtze River enters the sea. It is an important economic growth pole in China, an important intersection of the "Belt and Road" and the Yangtze River Economic Belt, and an important node for China to participate in the international division of labor and competition. The Yangtze River Delta has been actively exploring the cooperation mechanism for green economic development in recent years. In response to the call of "preferring green water and green mountains to golden mountains", the Yangtze River Delta regions have set up the Collaborative Group on Air Pollution Prevention and Control and the Collaborative Group on Water Pollution Prevention and Control to carry out the collaborative treatment in three aspects: air, water environment, and soil. We are actively promoting the reduction of construction land, and scattered highly polluting industrial enterprises are either moved into industrial parks or vacated and shut down. In 2011, Zhejiang Province and Anhui Province established China's first pilot eco-compensation mechanism for cross-provincial watersheds in the Xin'an River basin, and in 2012, they signed the Yangtze River Delta Emergency Response Work Plan for cross-border environmental pollution incidents. The Yangtze River Economic Belt Industry Blue Book: Report on the Development of Industries in the Yangtze River Economic Belt shows that the Yangtze River Delta city cluster ranks among the top in green development in the Yangtze River Economic Belt and even in China. In conclusion, the Yangtze

River Delta city cluster plays a leading role in the process of green transformation of China's economic and social development.

2. Status of Domestic and International Research and Literature Review

2.1. In the Current Situation of Green Economy Development and Green Economy Efficiency Assessment and Calculation

Zhang Xiaogang (2011) believes that the development of the green economy is conducive to the construction of "two types of society" and is a necessary way to lead to an ecological civilization society. Chen Yingzhi (2018) used the entropy-topics method to evaluate the level of economic green growth in the three eastern provinces and found that the overall level of green growth was still in its infancy. Some foreign scholars first proposed the measurement method, refined it, and constructed the directional distance function, which distinguishes output into desired output and non-desired output, and the Malmquist-Luenberger (ML) index constructed based on this function can measure the green economic efficiency. However, some scholars believe that the ML index is not solvable in linear programming when the payoffs to scale are variable, so the global Malmquist-Luenberger index (GML) is constructed by introducing a global production possibility set. Luenberger (GML), which not only overcomes the possible linear insolvency problem, but also makes the measured index satisfy the cyclic cumulative nature, so that the long-term growth trend of green productivity can be observed, thus the GML index is widely used by scholars; domestic scholars Yang Long and Hu Xiaozhen (40) named the ratio of regional GDP to regional environmental pollution index as the relative green GDP as an output indicator. The DEA model was introduced, and capital, labour and technology were used as input factors, and the results were used to analyse the green economic efficiency of 29 provinces in China; Qi, Yawei and Tao, Changqi (2012) used the directional distance function and the GML index to measure the green economic efficiency of each province and city in China, and found that the improvement of green economic efficiency depended on technological progress and the expansion of technology scale; Qian (2012) used the SBM-Undesirable model and DEA cross-efficiency model to measure the green economic efficiency of three industrial wastes as non-desired outputs; Yi and Ming et al. (2018) measured the green economic efficiency of the Yangtze River Economic Zone through the GML index and found that the green economic efficiency showed a W-shaped variation, which originated from the change in technological progress. By evaluating the green economic efficiency of each province in the economic belt between 2005 and 2017, Wu Chuanqing et al. (2020) found that the green economic efficiency of the region rose and then fell through a spatial model study, and the difference between provinces narrowed and then widened. Zhou Jiewen et al. (2020) took the provinces along the Belt and Road from 2000 to 2017 as the research object, and by measuring the green economic efficiency of each province, they concluded that the green economic efficiency of the provinces along the Belt and Road varied greatly and the overall level fluctuated. In addition, Hu Bowei et al. (2020) and Lin Xiao et al. (2017) took 20 resource-based cities in China's northern arid zone and 14 cities in the old industrial base in northeast China as research objects to explore the differences in the spatial and temporal distribution of green economic efficiency and the influencing factors. The above studies have laid a solid foundation for the measurement of green economic efficiency, but there are also some problems: due to the differences in their respective theories and research regions, scholars have chosen different indicators for the measurement, and there is no unified indicator to measure green economic efficiency. The new era has created new requirements for the study of green economic efficiency, and the research on this part is still insufficient.

2.2. Carbon Reduction Pathway Research

Zhou et al. (2014) designed a temporal, spatial and spatiotemporal carbon emission rights allocation model to maximize GDP, and found that the spatiotemporal allocation strategy takes into account carbon allowance trading in both time and space. Drawing on the model of Zhou et al. (2014), Zhang et al. (2020) explored the impact of carbon trading markets on the economic output and emission reduction performance of different industrial segments. Feng et al. (2015) constructed a centralized allocation model under two technical assumptions of CRS and VRS, and based on this, proposed a carbon emission reduction compensation mechanism. Since China proposed to achieve the carbon peak target by 2030, scholars have engaged in intense discussions on how to achieve carbon emission reduction in China. Wang Fengting et al. (2019) studied the relationship between carbon emissions and the economic growth of industries in Beijing, Tianjin, and Hebei using a decoupling model as well as a log-averaged Diez index model (LMDI), and explored the drivers of carbon emissions. Tong Xin et al. (2015) used the STIRPAT model and the grey model GM(1,1) to analyze the influencing factors and forecast the trend of carbon emissions in China. Li Qiang and Zuo Jingxian (2017) used the STIRPAT model to predict the likely timing of carbon peaking in the Yangtze River Economic Belt based on panel data from 2000-2014 for 11 provinces and cities in the Yangtze River Economic Belt. Zhang Yongqiang and Zhang Jie (2017) and Wang Rong and Xing Junling (2013) studied the decoupling relationship between economic development and carbon emissions in Guangdong and Shaanxi, respectively, using the Tapio model. Ma Yanmei et al. (2019) used ESDA and spatial econometric models to study the spatial correlation and spillover effects of industrial carbon emissions in 17 prefecture-level cities in Shandong, and Yu Xiang et al. (2020) studied the carbon emission reduction pathways of low-carbon pilot cities in China. Existing studies have made a lot of achievements in carbon emission forecasting, but most of them only analyze carbon emissions in China as a whole or in individual provinces, and there is a lack of a unified research framework for a comparative analysis of carbon emission peaks in the Yangtze River Delta region. As there are significant regional differences among the prefectures in the Yangtze River Delta region, only by designing different emission reduction scenarios can we help the Yangtze River Delta region and the whole country to identify the optimal carbon peak pathways.

3. Factors Influencing the Development of Green Economic Efficiency

Green economic efficiency is the core of the green economy, and its influence mechanism should be explored after its accurate and reasonable measurement, to serve the good development of the green economy. The research on the influence factors of green economic efficiency mainly focuses on the following aspects: regional economic development level, economic structure, environmental regulation, technological progress, human capital, and other factors.

3.1. The Influence of Regional Economic Development Level on the Efficiency of the Green Economy

The level of economic development is the proper meaning of a green economy and the important role of regional economic development in green economic efficiency. Most scholars use GDP per capita and its series of mathematical forms to measure the level of regional economic development. Qian Jingming and Liu Xiaochen found a significant inverted U-shaped relationship between green economic efficiency and economic development level in China based on Chinese provincial panel data from 1996 to 2010, which is consistent with the Kuznets environmental curve[8]; Wu Qi and Yang Guiyuan used Chinese provincial panel data to demonstrated that the economic development of most Chinese provinces and cities hurts green economic efficiency, i.e. continued economic growth leads to a decline in environmental benefits, indicating that most provinces are still in economic transition and have not achieved harmonious economic and ecological development. In other words, the impact of the level of

economic development on green economic efficiency varies depending on the region and time [4].

3.2. The Impact of Economic Structure on Green Economic Efficiency

Scholars usually conduct research on the industrial structure and the degree of opening up of the economy to the outside world. In terms of industrial structure, most of the indicators chosen are the ratio of secondary industry, tertiary industry to regional GDP, or the ratio of both. Zhang Wenbo et al. used a Tobit regression econometric model to study the main node cities of China's "Belt and Road" between 2005 and 2015, showing that there is a significant negative relationship between the proportion of the secondary industry and the green economic efficiency[5]. Li Yanjun and Hua Min's study on the structure of secondary industry using the instrumental variables method also supports the above findings[6]. Su Jiaxuan, on the other hand, used an econometric model to demonstrate that an increase in the tertiary share has a catalytic effect on green economic growth. In other words, previous studies have shown that the share of secondary and tertiary sectors have contradictory mechanisms of action on the development of a green economy[7]. In terms of the degree of opening up of the economy to the outside world, the representative indicators used in most of the literature are import and export trade and total foreign direct investment (FDI). On the one hand, some scholars believe that technology spillover from FDI can promote the efficiency of a green economy, for example, related studies by Barry, Reisen, and Antony show that capital investment in developed countries and host countries use the impact of technology spillover on industrial structure and resource allocation to improve the efficiency of green economy, while some domestic scholars have also produced the same studies[8][9][10]. On the other hand, some scholars argue that higher environmental standards in developed countries will cause their highly polluting enterprises to move to countries and regions with lower standards, thus exacerbating environmental pollution in FDI-inducing countries and reducing green economic efficiency. Lin Jihong and Liu Ying find that the "pollution paradise hypothesis" is theoretically feasible but lacks empirical validation because the endogeneity of environmental regulatory variables interferes with the robustness of the test results, and the role of "factor endowments" on FDI is often overlooked in research. Therefore, they used a panel econometric model with additional instrumental variables to overcome the endogeneity and tested the "pollution paradise hypothesis" for China based on data from 36 industrial sectors in China[11].

3.3. The Impact of Environmental Regulation on the Efficiency of the Green Economy

Environmental regulation requires governments to strengthen the management of the environment and environmental pollution reduction, avoiding economic growth at the expense of environmental damage. Although Porter's hypothesis suggests that environmental regulation can promote "innovation compensation" and improve the competitiveness of firms. Li Ling and Tao Feng, Li Bin, and others have also demonstrated empirically that environmental regulation has a 'U' shaped relationship with green total factor productivity and a 'threshold effect'[12][13]. According to Qian and Liu, there is a time lag between environmental regulation and green economic efficiency, and the long-term implementation of environmental regulation policies can significantly improve green economic efficiency, but this effect is spatially heterogeneous, with a promotion effect for eastern China and a suppression effect for central and western China[8].

3.4. The Impact of Technological Progress on Green Economic Efficiency

The contribution of technological progress to economic growth has been confirmed by theory and practice, and the relationship between it and green economic efficiency has attracted the attention of many scholars. Birol, Ma, Zhang, and Ma Hailiang argue that technological progress

can positively improve energy efficiency[14][15][16][17]. Based on data from 30 provinces in China from 2006 to 2009, Zhi Huawei showed that technological innovation can promote low-carbon economic development and suggested that more investment should be made in science and technology in the area of "energy saving and carbon reduction" [18]. However, there are also divergent views, such as Liu Dengguo and Guo Jingru, who argue that technological progress (expressed in terms of the number of patents granted) has no significant impact on China's environmental economic efficiency[19].

4. Relevant Studies on Green Economy in the Yangtze River Delta Region

4.1. Analysis of the Current Situation of the Yangtze River Delta Region

According to the Yangtze River Delta City Cluster Development Plan approved by the State Council, the Yangtze River Delta City Cluster includes 26 cities in Shanghai, Jiangsu Province, Zhejiang Province, and Anhui Province.

4.1.1. Economic Situation

In terms of the absolute economic scale, the GDP of the Yangtze River Delta region and the whole country has been increasing between 2005 and 2019 (see Figure 1)). Figure 1 shows the scale of GDP in the Yangtze River Delta region from 2007 to 2020; in 2007, the total GDP of the Yangtze River Delta region was RMB 53,963 billion, increasing to RMB 205,106 billion in 2020, an increase of nearly four times. In terms of the relative size of the economy, although the total GDP of the Yangtze River Delta region continues to increase, the Yangtze River Delta region's share of national GDP declined significantly between 2007 and 2008, falling to 19.56% in 2008 and then hovering at the 20% cut-off. The analysis of the region's economic indicators shows that the region is a leader in economic development, with high levels of fixed asset investment and fiscal expenditure, high levels of total consumption, a well-developed industrial and urban system, and sound infrastructure.

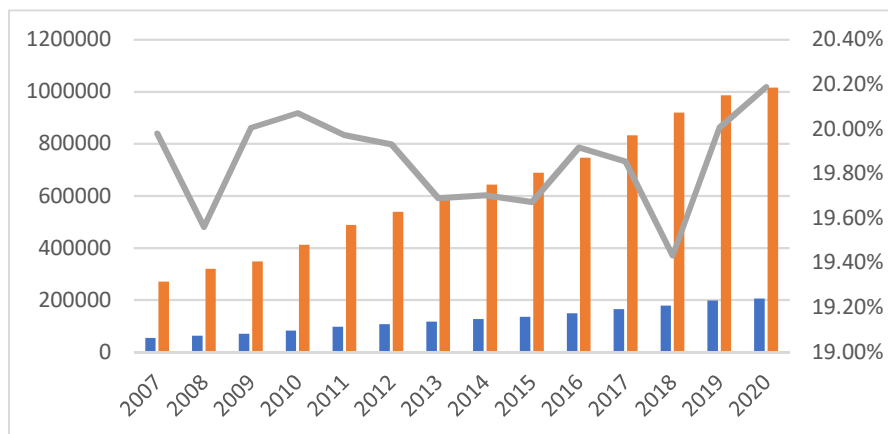


Figure 1. GDP of the Delta Region and its share in the country, 2007-2020 (in billions of yuan)

4.1.2. Population and Employment Situation

In general, the resident population and employment in the Yangtze River Delta urban agglomeration have been increasing, with the resident population increasing by 23.326 million and the urban resident population increasing by 36.0867 million over the 14 years from 2006 to 2019. The urbanization rate of the Yangtze River Delta urban agglomeration as a whole has increased significantly. In terms of employment, the number of people employed in the Yangtze River Delta city cluster has continued to rise in recent years, but the growth rate of employment has slowed since 2014. 74,817,700 people were employed in the Yangtze River Delta city cluster in 2006, and 98,478,900 people were employed in 2019, an increase of 23,661,200 people. By city, the distribution of resident population and employment is highly uneven across

cities. Specifically, Shanghai has the strongest ability to attract and gather population, with its year-end resident population and employment leading the way, with 24,281,000 and 13,762,000 people resident and employed in the region in 2019, while second place Suzhou had 10,750,000 and 6,926,000 people resident and employed, respectively, and Zhoushan, with the smallest resident population, had only 1,176,000 people employed. The gap with Shanghai is huge, with only 4200,800 people employed in Tongling. During the study period, Anqing and Yancheng cities had a lower resident population or employment in 2019 than they had in 2015, while all other cities had an upward trend in resident population and employment.

The degree of concentration of elements in the largest cities can be measured by the law of the primate city. The normal values of the law of the primate city and the four-city index by population are 2 and 1 respectively, according to the city ordinal-scaling rule, and the results in Table 1 show that law of the primate city in the Yangtze River Delta region is greater than 2, with a maximum deviation of 21.5%. The four-city index ranges from 0.82 to 0.88, all of which are less than the normal value of 1, with a maximum deviation of 18%, both of which are not far from the normal value. From a temporal perspective, both the law of the primate city and the four-city index of the Yangtze River Delta urban agglomeration converge toward their normal values. From the perspective of urban population distribution, it can be seen that the Yangtze River Delta urban agglomeration has a reasonable city size ranking, and the population size distribution converges to Zipf's law and does not deviate too much from the equilibrium state.

Table 1. City Primacy in the Yangtze River Delta Region, 2005-2019

	Law Of The Primate City	Four-City Index
2006	2.43	0.84
2007	2.34	0.85
2008	2.35	0.87
2009	2.36	0.88
2010	2.20	0.85
2011	2.23	0.86
2012	2.26	0.87
2013	2.28	0.87
2014	2.29	0.88
2015	2.28	0.87
2016	2.27	0.86
2017	2.26	0.85
2018	2.26	0.84
2019	2.26	0.82

4.1.3. Environmental Situation

The Yangtze River Delta region is one of the regions with serious ecological and environmental problems in China. The occurrence of air pollution, water pollution, soil pollution, acid rain, and ecological degradation hinders the sustainable development of the region. China has taken a series of measures to address environmental pollution problems and quality economic development, such as enacting environmental protection laws and pollution prevention laws, carrying out three major defense battles, establishing urban environmental protection systems, and vigorously developing a circular economy. As shown in Figure 2, industrial wastewater emissions in the Yangtze River Delta urban agglomeration decreased year by year between 2005 and 2017, and industrial sulfur dioxide emissions fluctuated, so that overall regional pollution prevention and control has achieved some success, but due to the different levels of economic development in each region, the level of governance varies from region to region.

This indicates that the Yangtze River Delta region has made the most progress in the prevention and control of air pollution, while further efforts are needed in the areas of wastewater, solids, and soil.

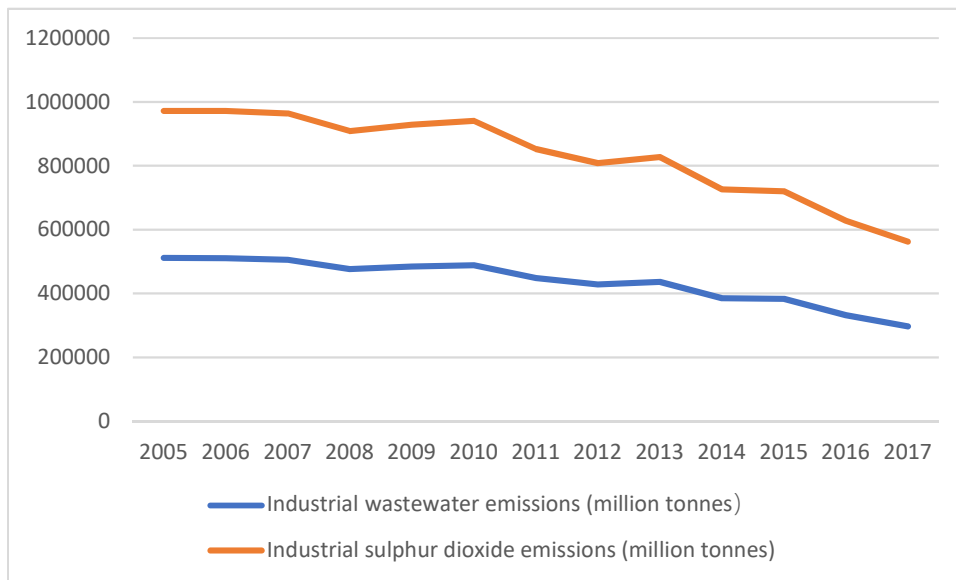


Figure 2. Changes in industrial wastewater and sulfur dioxide emissions in the Yangtze River Delta region, 2005-2017

5. Measurement of Green Development in the Yangtze River Delta Region

5.1. Establishment of the Evaluation System of Green Development Level in the Yangtze River Delta Region

This paper uses the Super-SBM model to measure the green economic efficiency values of 26 cities in the Yangtze River Delta city cluster from 2005 to 2018. In the measurement, each city is treated as a decision-making unit (DMU) of production, and the production possibility boundary of each period can be constructed based on multiple DMUs. It is assumed that there are n DMUs containing m inputs, s_1 desirable output, and s_2 undesirable outputs, in order, using the vectors x, y^g, y^b , where $x \in R^m, y^g \in R^{s_1}, y^b \in R^{s_2}$. Let the matrix $X = [x_1, \dots, x_n] \in R^m \times n, Y^g = [y_1^g, \dots, y_n^g] \in R^{s_1} \times n, Y^b = [y_1^b, \dots, y_n^b] \in R^{s_2} \times n$, and $X > 0, Y^g > 0, Y^b > 0$. The set of production possibilities $P = \{(x, y^g, y^b) | x \geq X\lambda, y^g \leq Y^g\lambda, y^b \geq Y^b\lambda, \lambda \geq 0\}$, where λ is the weight vector and the above represents the case of constant returns to scale (CRS).

In summary, the Super-SBM model can be expressed in the following form:

$$\theta^* = \min \frac{1 - \frac{1}{m} \sum_{i=1}^m \frac{s_i^-}{x_{i0}}}{1 + \frac{1}{s_1 + s_2} \left(\sum_{r=1}^{s_1} \frac{s_r^g}{y_{r0}^g} + \sum_{r=1}^{s_2} \frac{s_r^b}{y_{r0}^b} \right)}$$

$$s. t. \begin{cases} x_0 = X\lambda + s^- \\ y_0^g = Y^g\lambda - s^g \\ y_0^b = Y^b\lambda + s^b \\ s^- \geq 0, s^g \geq 0, s^b \geq 0, \lambda \geq 0 \end{cases}$$

In the above equation s^- , s^g , s^b denote input slack, desired output slack, and non-desired output slack, respectively. θ^* is the estimated efficiency value, with larger values indicating more efficient decision units. If the green economic efficiency value is not less than 1, the city's production is efficient, if the value is less than 1, the city's production is inefficient. Referring to the practice of scholar Qian Jingming and scholar Dong Xiaojun, the indicators selected for the green economic efficiency measurement in this paper are shown in Table 2:

Table 2. Evaluation system for green development in the Yangtze River Delta region

Indicators			
Input	Non-resource input	Workforce	At the end of the year, the total number of employed persons per unit, urban private sector and self-employed persons (10,000 persons)
		Capital	Annual Fixed capital investment (\$0,000)
		Science and Education	Science and education expenditure as a percentage of local general financial expenditure(%)
	Resource class input	Land resources	The built-up area (square kilometers)
		Water Resources	Total annual water supply (10,000 tons)
		Energy	Total annual electricity consumption (10,000 kilowatt-hours)
Expected output	GDP		Based on 2005, the actual CDP of each year (billion yuan) is calculated
Undesired output	Discharge of industrial wastewater (10,000 tons)		
	Industrial SO2 emissions (ton)		
	Industrial smoke (dust) emissions (tons)		

5.2. Current Situation of Green Development in the Yangtze River Delta

According to the calculation results, the following conclusions can be found: (1) In general, the green economic efficiency of the Yangtze River Delta city cluster has fluctuated around 0.8 during the study period, with little change overall, and its green economic efficiency level needs to be further improved. (2) By province and city, Shanghai's green development is efficient, with its green economic efficiency value exceeding 1 from 2005 to 2018, which is higher than the green economic efficiency of the Yangtze River Delta urban agglomeration as a whole, and Shanghai's green development plays a leading role in the Yangtze River Delta urban agglomeration, which is important for achieving the green and high-quality development of the Yangtze River Delta urban agglomeration as a whole. The average green economic efficiency value of the nine cities in Jiangsu Province fluctuates upwards, and its green development level is higher than that of Anhui Province and Zhejiang Province, and the average green economic efficiency value exceeds that of the Yangtze River Delta urban agglomeration as a whole; the average green development level of the eight cities in Zhejiang Province tends to decline, and

fails to contribute to the green development of the region as a whole; Anhui Province has the lowest green development level, and its green economic efficiency value is always below 0.6, which is lower than the average value of the Yangtze River Delta as a whole. (3) By city, there are at least 12 cities with a green economic efficiency value of less than 1 per year, accounting for more than 46% of the total, and more than 10 cities with a green economic efficiency value of less than 0.6 per year, with Nanjing, Changzhou, Yangzhou, and Zhenjiang being the most unproductive areas in Jiangsu Province, all concentrated around the Nanjing metropolitan area. In Zhejiang Province, except Jinhua and Taizhou, other cities have experienced low productivity in different years. The eight cities in Anhui Province are mostly characterized by low production efficiency, except for a few years when the production efficiency value is occasionally above 1. The realization of green development in Anhui Province is particularly important for improving the overall green development of the Yangtze River Delta. Anhui province joined the Yangtze River Delta city cluster in 2016 and has not yet formed a good linkage with other provinces and cities. The province's industrial structure is laid out as "two, three, one", with the secondary industry being highly polluting and energy-intensive. Zhejiang should play the role of a "conveyor belt" to better connect Shanghai and Anhui and achieve coordinated regional development.

6. Policy Recommendations.

First, promote industrial clustering and industrial structure upgrading. Expand the scale of "science and innovation enclaves" and further agglomerate high-tech and industrial industries. Actively develop tertiary industries and modern industries, promote the popularisation of clean energy, share green production technologies, and promote innovation in green technologies. Breaking down technological barriers and promoting the positive diffusion of knowledge spillovers between regions, and promoting the sharing of technology and innovation between regions. Adjust the energy structure, reduce the use of coal, research and develop new environmentally friendly energy sources, promote the use of clean energy sources such as solar and wind power, and achieve source control of pollutants in industrial production. Improve and improve the compensation mechanism for green innovation, encourage enterprises that can do so to invest more research and development costs in the development of green innovation technologies, and provide more financial subsidies for process-integrated innovation to incentivize enterprises to innovate in process-oriented green technologies. For those enterprises that do not meet the pollution emission standards, or even emit pollutants illegally, fines or even closure should be imposed to force them to take the path of environmentally friendly production. Improve inter-enterprise carbon emissions trading policies and implement market-oriented pollution emissions. Implementing the strategy of strengthening the country through science and education, strengthening the cooperation between universities, research institutes, and enterprises, promoting the linkage and cooperation of talents, technology, and capital, and using green technology development to drive the optimization and upgrading of industrial structures, thereby enhancing the efficiency of the regional green economy.

Second, increase the intensity of regional environmental regulations. Raise regional awareness of environmental protection, promote the formulation and implementation of uniform and high-standard environmental policies, strengthen the enforcement of environmental regulations, and promote the intensity of environmental regulations to force enterprises to carry out green technological innovation, thereby realizing green economic development. The intensity of environmental regulation depends on the environmental awareness of local governments. The central government should do a good job of top-level design, innovate the performance assessment system of local governments, and incorporate environmental

management results into the assessment of officials' promotion mechanisms to draw attention to environmental pollution from the top down. Strengthen the monitoring and control of cross-regional pollution emissions, and implement a system of responsibility for pollution control by "the one who pollutes is the one who controls". At the same time, an eco-compensation mechanism will be set up, whereby polluters will pay the polluted areas an amount to treat the environment. The pilot project of the Yangtze River Delta Eco-Green Integrated Development Demonstration Zone will be gradually promoted, and a unified and high-standard environmental policy will be set up to turn ecological advantages into economic advantages, to play a leading role in the demonstration zone.

Thirdly, the deep integration of manufacturing and productive services. Governments at all levels in the Yangtze River Delta region must adhere to the "two-wheel drive" development strategy, rely on the good industrial foundation of the Yangtze River Delta region, continuously reduce transaction costs, optimize the production environment and enhance industrial competitiveness, with the goal of enhancing the embedding of the value chain and creating conditions for deep synergy between manufacturing and productive service industries. Further promote the synergistic development of the financial services, scientific research, technical services, geological exploration industries, and the manufacturing industry, and enhance the positive effect of the synergistic clustering of these two types of productive services and manufacturing industries on the development of the city's green economy. Effectively guide the synergistic development of the information transmission, computer services, and software industry, and the manufacturing industry, and rely on information technology to promote the intelligence and greening of the manufacturing industry. At the same time, the synergistic development of rental and business services, transportation, storage, and postal services, and the manufacturing industry will be strengthened, relying on transportation facilities and information technology to accelerate the free flow of factors between cities.

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