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Future Environmental Change Trends in the Yangtze River Delta and Pearl River Delta Regions with Modern Governance Achievements: Theoretical, Current Status and Policy Research

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Abstract. This study focuses on the prediction of the Environmental Kuznets Curve (EKC) and inflection point issues in the Yangtze River Pearl River Delta basin in the future, and conducts an in-depth analysis by comprehensively applying multiple research methods. By combing the theoretical evolution of the Environmental Kuznets Curve, this study clarifies its historical process from proposal to development and its morphological changes in different contexts. Based on the current status of China's economy and environment, it is found that there is a complex relationship between economic growth and environmental pollution at the current stage. Although the emissions of some pollutants show a downward trend, the overall situation remains severe, and the timing of the inflection point is constrained by multiple factors. On the basis of analyzing influencing factors such as industrial structure, technological innovation, and environmental policies, this study constructs a dynamic computable general equilibrium model (CGE) to simulate the impacts of different policy combinations on the curve's inflection point, puts forward targeted policy recommendations to promote the coordinated development of economy and environment, and provides theoretical support and decision-making basis for China to achieve sustainable development.

Keywords: Environmental Kuznets Curve (EKC), prediction, inflection point, sustainable development, environmental governance

1. Introduction

With the rapid global economic development, environmental issues have become increasingly prominent, emerging as key constraints to the sustainable development of human society. Since the Industrial Revolution, countries worldwide have pursued economic growth through large-scale exploitation and utilization of natural resources, leading to severe environmental pollution—such as air, wate r, and soil pollution—which poses significant threats to ecosystem balance, human health, and the stable development of economic and social systems. Against this backdrop, exploring the

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balance between economic growth and environmental protection has become a focal point for academia and policymakers.

The Environmental Kuznets Curve (EKC), a theoretical model describing the relationship between economic growth and environmental quality, provides a critical framework for studying the dynamic evolution of this relationship. However, the theory's applicability varies across countries and regions, with its shape and inflection point influenced by multiple factors. In-depth research on the future EKC in the Yangtze River Pearl River Delta region can further enrich and refine this theory, expanding its application and understanding in the context of developing countries, while offering new perspectives and empirical evidence for interdisciplinary research in economics and environmental science.

Practically, accurate prediction of the trajectory and inflection point of China's EKC can assist governments in formulating more precise and effective environmental policies. Clarifying the approximate timing and conditions for the inflection point enables policymakers to adjust industrial structures, increase environmental investment, and promote technological innovation—guiding the economy toward green and sustainable development, improving environmental quality alongside economic growth, and avoiding the lessons drawn from others' mistakes of "pollution first, governance later." For enterprises, understanding EKC trends helps them pre-emptively adjust production and operational strategies to adapt to increasingly stringent environmental requirements and enhance competitiveness. For the public, research findings can strengthen environmental awareness and foster active participation in environmental protection efforts.

By reviewing domestic and international literature on the relationship between economic development and environmental quality, this study draws insights to apply the Environmental Kuznets Curve (EKC) framework for analyzing the relationship between economic development and environmental quality in the Pearl River Delta region.

2. Literature review

2.1. Research status of the Environmental Kuznets Curve (EKC)

Research on the Environmental Kuznets Curve (EKC) abroad started relatively early. In 1991, American economists Grossman and Krueger [1] first proposed the phenomenon that "pollution increases with the growth of per capita GDP at low-income levels and decreases with GDP growth at high-income levels" when studying the relationship between environmental quality and per capita income in the negotiation of the North American Free Trade Area.

In 1993, Panayotou[2] borrowed the inverted U-shaped curve between per capita income and income inequality defined by Kuznets, and formally named this relationship between environmental quality and per capita income the environmental Kuznets curve (EKC).Since then, many scholars have conducted extensive and in-depth research around EKC.

In terms of empirical research, some scholars have verified the existence of EKC by analyzing data from different countries and regions. Holtz- Eakin, Selden[3] calculated the result is between US335,428 and US 80,000. In addition, studies have found that there are many different forms such as U-shaped, N-shaped, monotonically rising, and monotonically declining between environmental quality and income.

In terms of theoretical research, scholars have conducted in-depth discussions on the formation mechanism of EKC. Grossman and Krueger proposed that economic growth affects environmental quality through three ways: scale effects, technological effects, and structural effects. In terms of scale effects, economic growth on the one hand increases investment and thus increases the use of

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resources, on the other hand, more output leads to increased pollution emissions, which have a negative impact on environmental quality; in terms of technological effects, high income levels are closely linked to better environmental protection technologies and high-efficiency technologies, and technological progress can increase productivity, improve resource utilization efficiency, and reduce pollution emissions per unit of output; structural effects are manifested as income levels increase, the output structure and input structure change, and the early economy shifts from agriculture to energy-intensive heavy industry to increase pollution emissions, followed by the development of low-polluting service industries and knowledge-intensive industries, reducing the emission level per unit of output and improving environmental quality. In addition, factors such as environmental quality requirements, environmental regulations, market mechanisms, and pollution reduction investment are also included in the theoretical explanation of EKC. With the deepening of research, Arrow et al. criticized EKC for assuming that income is only an exogenous variable, and did not consider the impact of environmental degradation on the process of production activities and future income. It is necessary to construct a model that internalizes income to explore the interaction between environmental quality and income level. At the same time, the study also found that there are limitations to the applicability of EKC, such as the inability to reveal the effects of stock pollution, and it may show an N-shaped curve in the long term.

2.2. Discuss the current situation of the Pearl River Delta in combination with theory

The environmental Kuznets curve (EKC) theory believes that in the early stages of economic growth, environmental quality will deteriorate with economic development. When economic development reaches a certain stage, environmental quality will gradually improve, and the two have an inverted U-shaped relationship.However, judging from the data from 2004 to 2018 in the Pearl River Delta region, the actual situation is more complicated.

Judging from the economic development data (Figure 1), the economic growth of the Pearl River Delta region is strong. In 2004, the region's gross domestic product was 1561.563 billion yuan, and it will grow to 8689.905 billion yuan by 2019, with an average annual growth rate of about 12.45%. The GDP per capita has also continued to rise from 2004 to 136,334.91 yuan in 2019. In terms of industrial structure, the proportion of the gross domestic product of the first, second and third industries in 2004 was 3.59%, 49.62%, and 46.79%, respectively. By 2019, this proportion will become 1.64%, 41.26%, and 57.10%. The proportion of the tertiary industry has increased significantly, becoming the leading industry, and the industrial structure has been continuously optimized and upgraded, which is in line with the general trend of economic development.

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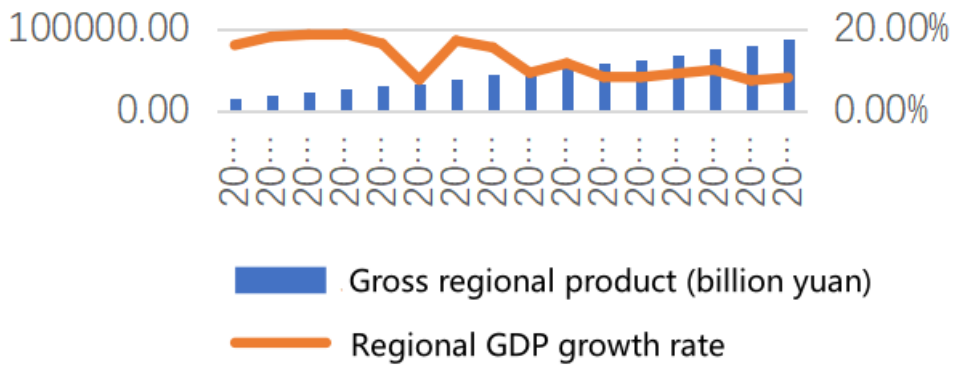

Figure 1: The GDP and GDP growth rate of the Pearl River Delta region [4]

However, in terms of environmental quality, the performance of the Pearl River Delta region is not completely consistent with the traditional EKC theory. Taking industrial wastewater discharge as an example (Figure 2), the discharge of industrial wastewater in 2004 was 1.001.05 million tons, and then it increased year by year, reaching a maximum value of 1.767.42 million tons in 2007. Although there were fluctuations afterwards, the overall trend was downward, and the emissions decreased in 2018. Through the fitting of the model, it is concluded that the discharge of industrial wastewater has an inverted U-shaped curve relationship with the per capita GDP, and the per capita GDP at the inflection point is about 72,941.17 yuan, which is between 2010 and 2011. This shows that the discharge of industrial wastewater has declined with the economic development since then, indicating that the Pearl River Delta region has achieved certain results in water environment governance.

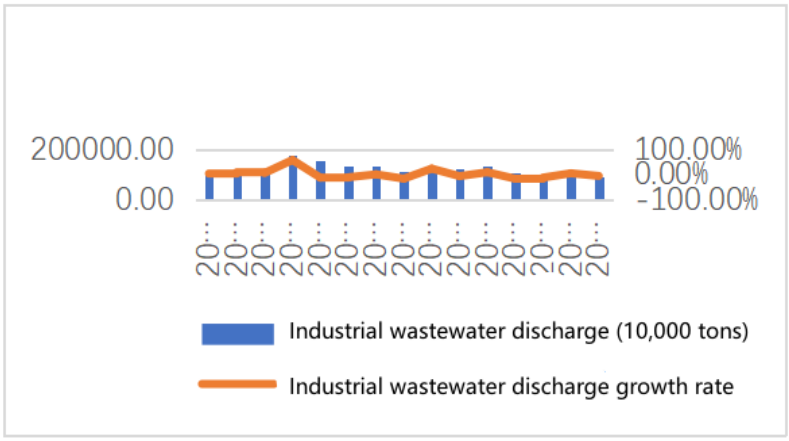

Figure 2: The growth rate of industrial wastewater discharge and discharge in the Pearl River Delta region from 2004 to 2008 [4]

However, according to Figure 3, the situation of industrial exhaust emissions is different. From 2004 to 2018, industrial exhaust emissions generally showed an upward trend. Although the "Guangdong Province Pearl River Delta Clean Air Action Plan" was issued and implemented in 2010, the governance effect was not obvious. Judging from the model, industrial exhaust emissions

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have an inverted N-curve relationship with per capita GDP, and the two inflection points are 14913.17 yuan and 545795.70 yuan per capita GDP respectively. Since the per capita GDP of the Pearl River Delta region has exceeded 14,913.17 yuan since 2004, it is currently in a stage of increasing emissions according to the curve trend; furthermore, the per capita GDP in 2019 is 136,334.91 yuan, which remains significantly below the second inflection point. This indicates that industrial exhaust emissions may continue to rise with economic growth for some time.

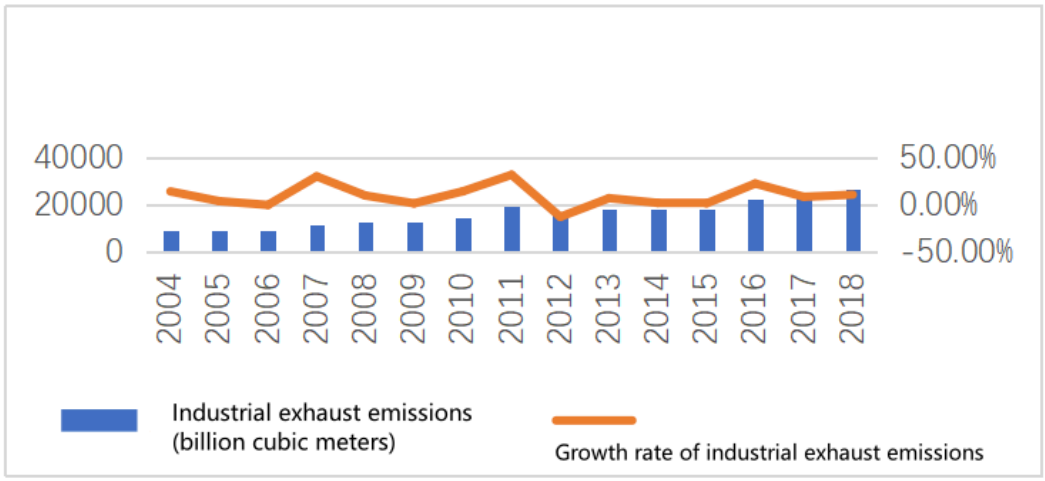

Figure 3: The growth rate of industrial exhaust emissions and emissions in the Pearl River Delta region from 2004 to 2008 [4]

The changes in the production of industrial solid waste are also more complicated. According to Figure 4, there was an upward trend from 2004 to 2012, a decline from 2012 to 2016, and a continuous increase after 2016. It has an inverted N-shaped curve relationship with per capita GDP. The two inflection points are 35,134.24 yuan and 62,124.46 yuan per capita GDP, respectively, between 2004-2005 and 2009-2010. In theory, it has entered a decreasing stage, but in practice it has risen again in the later stage, indicating that its governance faces many challenges.

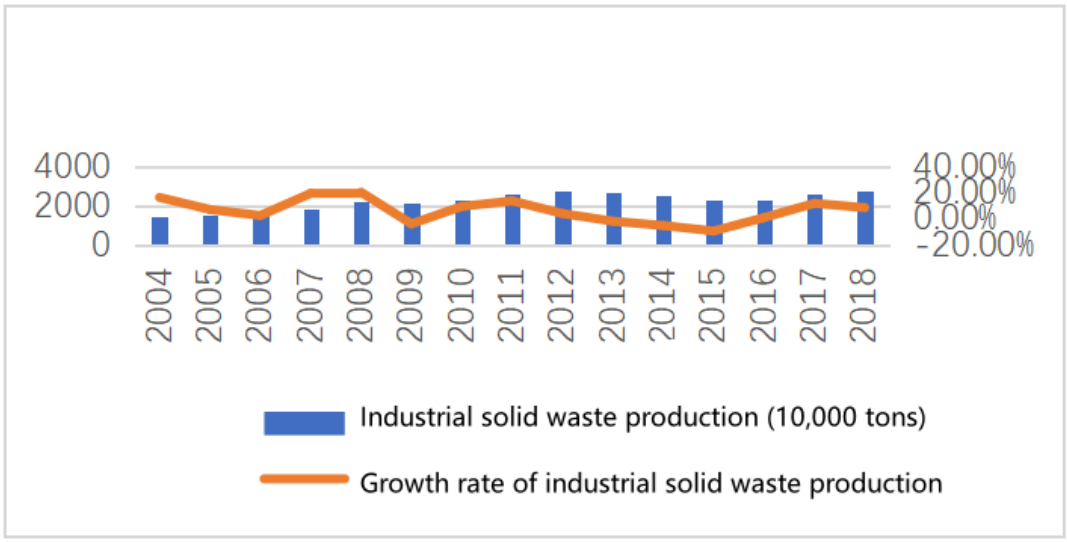

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Figure 4: The production and growth rate of industrial solid waste in the Pearl River Delta region [4]

In summary, the economic development achievements of the Pearl River Delta region have been outstanding, but the environmental quality situation is complex and diverse, and the traditional EKC theory cannot fully explain the environmental and economic relationship in the region. This shows that in the process of promoting economic development and environmental protection, the Pearl River Delta region cannot simply copy the theory. It needs to formulate more targeted policies and measures based on its own actual situation in order to achieve coordinated and sustainable economic and environmental development.

2.3. Environmental quality requirements that affect the environment Kuznets curve

Environmental quality requirements are another important factor affecting the environmental Kuznets curve. In the stage of low-level economic development, people's main focus is on meeting basic material life needs, such as solving the problem of food and clothing, and obtaining basic living and medical conditions. At this time, due to the limited income level, people's attention to environmental quality is low, and their willingness to pay for a good environment is also weak. In this case, in order to pursue economic growth and improve living standards, it is often at the expense of the environment to increase the development and utilization of natural resources, resulting in increased environmental pollution. For example, in some poor areas, in order to develop the economy, some high-polluting and high-energy-consuming industries may be introduced, ignoring the protection of the environment.

With the development of the economy and the improvement of income levels, people's living standards have been significantly improved. After basic material needs have been met, the requirements for quality of life have also increased day by day. At this time, environmental quality, as an important part of the quality of life, has gradually attracted people's attention and attention.People are beginning to realize the importance of a good environment for physical and mental health and well-being in life, and the demand for environmental resources such as clean air, clean water, and beautiful natural landscapes is increasing. This change in demand for environmental quality is not only reflected in people's consumer behavior, such as being more inclined to buy environmentally friendly products and choosing to live in areas with beautiful environments, but also in terms of public opinion and political participation. The public's attention to environmental protection has increased, and concerns about environmental issues have been expressed through various channels, forming strong public opinion pressure, prompting the government to strengthen environmental protection legislation and supervision, and promoting enterprises to adopt more environmentally friendly production methods. At the same time, people are also willing to pay higher costs for improving environmental quality, such as paying environmental taxes and supporting investment in environmental protection projects.

3. Prediction of future environmental change trends and environmental governance strategies in the Yangtze River and Pearl River Delta

It is obvious that under the strong promotion of the carbon neutrality policy, the environmental quality of the Yangtze River and Pearl River Delta will undoubtedly be improved.However, to fully transform the policy vision into reality, a series of specific and effective implementation measures are still needed.

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Looking back on the past, the safeguards for environmental governance in the Yangtze River and Pearl River Delta regions mainly revolve around publicity and education, scientific and technological support, economic compensation, and accountability.[5]

However, air pollution in the Pearl River Delta has shown significant regional effects, and air pollution between cities has obvious mutual effects. In other words, the air pollutant emission reduction measures implemented by Guangdong, Hong Kong and Macau have contributed to the gradual improvement of the overall air quality in the Pearl River Delta.

Therefore, in the current government's environmental governance strategy, there has been the establishment of a regional joint defense and joint control working mechanism, and joint defense is based on joint governance.At the same time, in order to ensure the accuracy of existing governance, a “monitoring platform” has been built to target governance based on the pollution characteristics of the Pearl River Delta.[6]

However, today's governance still needs to be combined with the development of technology. The current Yangtze River Delta region should use a big data information platform to realize one-click disclosure of sources of ecological environmental pollution, so as to figure out the release law of pollution investigation.

In addition, the key factors affecting the behavior strategy of ecological governance in the Yangtze River Delta region are the additional costs that the public needs to pay to participate in ecological governance, the benefits and subsidies obtained by enterprises when they actively manage the ecological environment, and the costs and fines paid by local governments when they relax regulations on the ecological environment.[7]

Therefore, in addition to strengthening follow-up and verification, clarifying the source of pollution and punishing the relevant responsible parties, the local government may also consider setting up a regulatory fund to subsidize stakeholders who actively participate in ecological and environmental protection and have achieved remarkable results; at the same time, it will impose penalties on entities that destroy the ecological environment, include fines in the regulatory pool, and ensure the openness and transparency of capital flow, rewards and punishments, so as to motivate all parties to actively participate in ecological governance.

4. Conclusion

The research of this paper is based on the environmental Kuznets curve theory. After analyzing the economic and environmental data of the Pearl River Delta region from 2004 to 2019, it was found that the traditional inverted U-shaped EKC theory is difficult to fully explain. The relationship between economic growth and environmental pollution in this region is complex. With economic development, the main industries in the Yangtze River and Pearl River Delta basin have gradually changed from traditional industries to tertiary industries, and the tertiary industry has gradually occupied a dominant position.

After combining the EKC theory, it can be concluded that the relationship between regional industrial wastewater emissions and per capita GDP is inverted U-shaped, but the relationship between the corresponding industrial waste emissions and per capita GDP is inverted N-shaped, and there is no traditional EKC curve. The former is still in the stage where emissions rise with economic growth, and the latter's governance effect fluctuates and rebounded, indicating that its evolution is affected by multiple factors such as industrial structure upgrading, policy intervention, and technological innovation, but there are problems such as insufficient effectiveness of joint prevention and control of regional pollution and lagging in the transformation of high-energy-consuming industries. However, combined with existing information and data, it can be predicted

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that industrial waste will gradually reduce emissions with economic development and policy support.

This research is limited to industrial pollutants and the latest data for 2025, and does not fully take into account the cumulative effects of policy variables promoted by China's positioning as an industrial country under the current international division of labor on environmental quality, as well as the lack of quantitative assessment of the implementation effect of existing environmental governance measures.

References

[1] Gene M. Grossman & Alan B. Krueger, (1994), Economic Growth and the Environment | NBER, 2-4
[2] Tisorn Songsermsawas, (2010), Income, Trade and Pollution in Central Asia, Russia and China: An Econometric Analysis, 5
[3] Douglas Holtz-Eakin &Thomas M. Selden, (1995), Stoking the fires? CO2 emissions and economic growth, abstract
[4] ZHIWANG:XIA Yunzhi, (2019), Research on the relationship between Economic Growth and Environmental Quality in the Yangtze River Delta Region, 4-8
[5] Guangdong Provincial Public Security Department. (2024). Notice on the issuance of Guangdong Province's Pearl River Delta Clean Air Action Plan—The Second Phase (2013-2015) Implementation Plan for Continuous Air Quality Improvementhttps://gdga. gd. gov. cn/xxgk/zcwj/content/post_1088788. html
[6] Ministry of Ecology and Environment of the People's Republic of China. □2019□. Guangdong wins the battle for the blue sky, the Pearl River Delta builds a model for the prevention and control of air pollutionhttps://www. mee. gov. cn/ywgz/xcjy/shxc/201909/t20190909_733028. shtml
[7] Wang, Qing &Mao ChunMei. (2024). Evolutionary Game Analysis of Ecological Governance Strategies in the Yangtze River Delta Region, China. 17-18