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Original Research Article

Does China's Carbon Intensity Decline with Economic Growth? Evidence from 1965–2024

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Abstract

China has high-speed development in the long term, while environmental protection is also given importance by society. The evidence of China can be analyzed and emulated by other countries. The project of ESG is popular globally, and the carbon intensity is considered an essential factor for the country, and economic growth may decrease the carbon intensity because economic growth is fueled by industry transition. The primary and secondary industries are not as efficient as the tertiary industry. This essay can give evidence to policymakers or independent units to make decisions under sustainable development. This study uses Stata software to conduct the analysis, and the analysis employs Chinese economic data and carbon-related data from world bank and the OWID CO_2 Dataset, respectively, from 1965 to 2024. The model chooses Carbon Intensity as the dependent variable and chooses Economic Growth as the independent variable. After that, the model employs Coal CO_2 Emissions per Capita, Services, Value Added (% of GDP), and Oil CO_2 Emissions as the Control Variables. From the empirical analysis, we can draw the conclusion that Economic Growth and Services, Value Added (% of GDP) are significantly associated with carbon intensity. And Coal CO_2 Emissions per Capita and Oil CO_2 Emissions are positively significantly associated with carbon intensity. China is an acute evidence for the developing countries to conduct an industry transition, and the carbon intensity decrease associated with a high-quality environment, which benefits all the citizens living in the country. The air conditioning and temperature also affect the earth ecosystem indirectly. China is still investing human, political, and capital resource to the tertiary industry and is accelerating the industry transition, which boosts its economic growth. Environmental protection should be put in the right place and be associated with the quality of living standards.

Keywords: Carbon Intensity, Economic Growth, Energy Structure, Industrial Transformation, China.

1. INTRODUCTION

With the development of Chinese technology and industry, the Chinese government is going to pay more attention to Chinese environmental protection. Carbon dioxide is a core index to reflect environmental protection and mitigate the greenhouse effect. China, as the core country to join paris agreement in 2016, has the duty to develop green technology and optimize the industry structure. The government repeatedly emphasizes the principle that "lucid waters and lush mountains are invaluable assets," highlighting the equal importance of economic prosperity and ecological sustainability.

Numerous developing countries' s economic data show that the industry expansion is associated with more carbon dioxide emissions, which leads to global warming, arctic ice melt, and sea level rise. This is also the earth challenge that all countries faced, so China, as one of the five permanent members of the United Nations Security Council, should shoulder the duty and change the industry structure to decline the carbon intensity. Chinese technology, such as new energy vehicles and clean robotic machines, is growing to reduce exhaust emissions. China has the fastest economic development speed during the last 30 years globally, so this paper is to using macroeconmomic data to investigate the question: Does China's Carbon Intensity Decline with Economic Growth?

2. LITERATURE REVIEW

Industry expansion is likely the main reason for the country to emit more carbon dioxide, and this is the pain point that most developing countries don't sign the agreement to join the group to protect the environment. Many scholars also pay attention to this phenominen, Amin *et al*., (2025) focus on the Chinese energy transition and conduct empirical analysis to give the

conclusion that technology and innovation will transform the resource-consuming industry to environment-friendly industry. Çobanoğulları (2024) also used the ARDL model to dig into the truth about the relations among CO2 emissions, health expenditure, and economic growth in Türkiye. Dilanchiev *et al*., (2024) found that a country utilized new energy to fuel the industry will get more efficiency compared to traditional energy and can generate less CO2. This way is a healthier economic development method in a continuous society. Du *et al*., (2024) found that China is boosting the digital industry and is empowering the entire industry, which can decrease the carbon intensity and give the citizens a better living environment. Kartal *et al*., (2024) pointed out that coal fuels can generate CO2 and is the major role that pollute the air, making the global warming effect worse. So China and India is going to use new energy to substitute traditional energy to protect the ecosystem. Zhang and Liu (2024) paid attention to China's CO2 emissions employing Kaya-LMDI for the period 1991–2022. They pointed out that China used to burn cheap energy to fuel its fast development. After their economic growing slow, the government invested in digital technology to utilize the industry structure. This is a pleasure method that citizens will thump up and also protect their own air condition, especially due to air pollution. Gbadeyan *et al*., (2024) emphasized that Carbon emission always linked with high-speed economic development, because the second industry is highly energy-intensive. Industrialization will produce a large amount of emissions, which contributes the global warming and sea lever rising. Iorember *et al*., (2024) argued that decoupling carbon emissions from economic growth is a necessary way for most developing countries, while green technology is so common and can help developing countries to boost industry development without using traditional energy. Yuan *et al*., (2024) showed that Decoupling and decomposition analysis of industrial carbon emissions and economic growth in China is a tough way to go. The Chinese economy is under pressure, and they need to employ new edge technology and innovation to promote productivity growth.

Raihan (2024) demonstrated that FDI is a useful factor to utilize the industry structure, and Southeast Asian countries like Vietnam can attract more FDI inflow to give a hand for domestic digital industry progress. Zeng *et al.,* (2024) revealed that ESG is a cutting-edge topic for the earth, and sustainable development should be considered as the top priority for all countries. Green innovation will generate wealth and boost the market in the future. Sun *et al*., (2024) concluded that China's road of economic transition can be mimicked by other developing countries. While China is a labor-intensive country and trade the manufacture product toward the world. Shipping the little manufacturing product to the global market to earn foreign exchange, and this make china great again in the 21st century. Tang *et al*., (2024) highlighted that carbon emission reduction is a hard thing to complete, because for most developing countries' citizens, their goal is earning wealth instead of protecting the environment.

To sum up, the economic growth is connected with carbon emission most of the time, but with the development of digital technology and green innovation, more and more countries accept the concept of sustainable development. This paper is going to focus on the relation between carbon intensity and economic growth.

3. Model Construction

Drawing from a consistent stream of broad economic data and robust theories linking the economy with the environment, this paper has identified four main factors: the rate of economic growth, carbon emissions per capita. So, the paper puts together this multiple regression model as fellows.

$$\ln CPD_t = \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln CCP_t + \beta_3 \ln SVD_t + \beta_4 \ln OCO_t + +\varepsilon_t \qquad (3-1)$$

In the above model, the paper shows that: CPD_t represents China's carbon intensity, measured as CO_2 emissions per unit of GDP. GDP_t Measures economic growth. CCP_t denotes coal-related CO_2 emissions per capita. SVD_t is the share of services value added in GDP. OCO_t Denotes total CO_2 emissions from oil consumption. Equation (3-1) allows examination of how economic activity, energy structure, and industrial upgrading jointly influence China's carbon intensity.

4. Data Introduction

4.1 China's Carbon Intensity

China is one of the top 2 large countries in the world in terms of GDP Volume. Its carbon intensity also plays a major role in the Earth. Chinese citizens also employ the high-level live standard of living, so this generate plunt of carbon dioxide, the manufacturing industry and industrial sector make the carbon intensity get higher. This is why China's role in global warming is so essential. The Chinese population is the second largest in the world, and only slightly less than that of India. By the way, Chinese GDP per capita is larger than India, and China has a more complete industrial value chain. These all factors give the value for the carbon intensity. The factor of carbon intensity is going to be the core factor, which is considered the essential environmental point in the ESG society. Chinese corporations also try to save energy to meet the requirements of ESG duty. That's the current status of Chinese carbon intensity fluctuat reason.

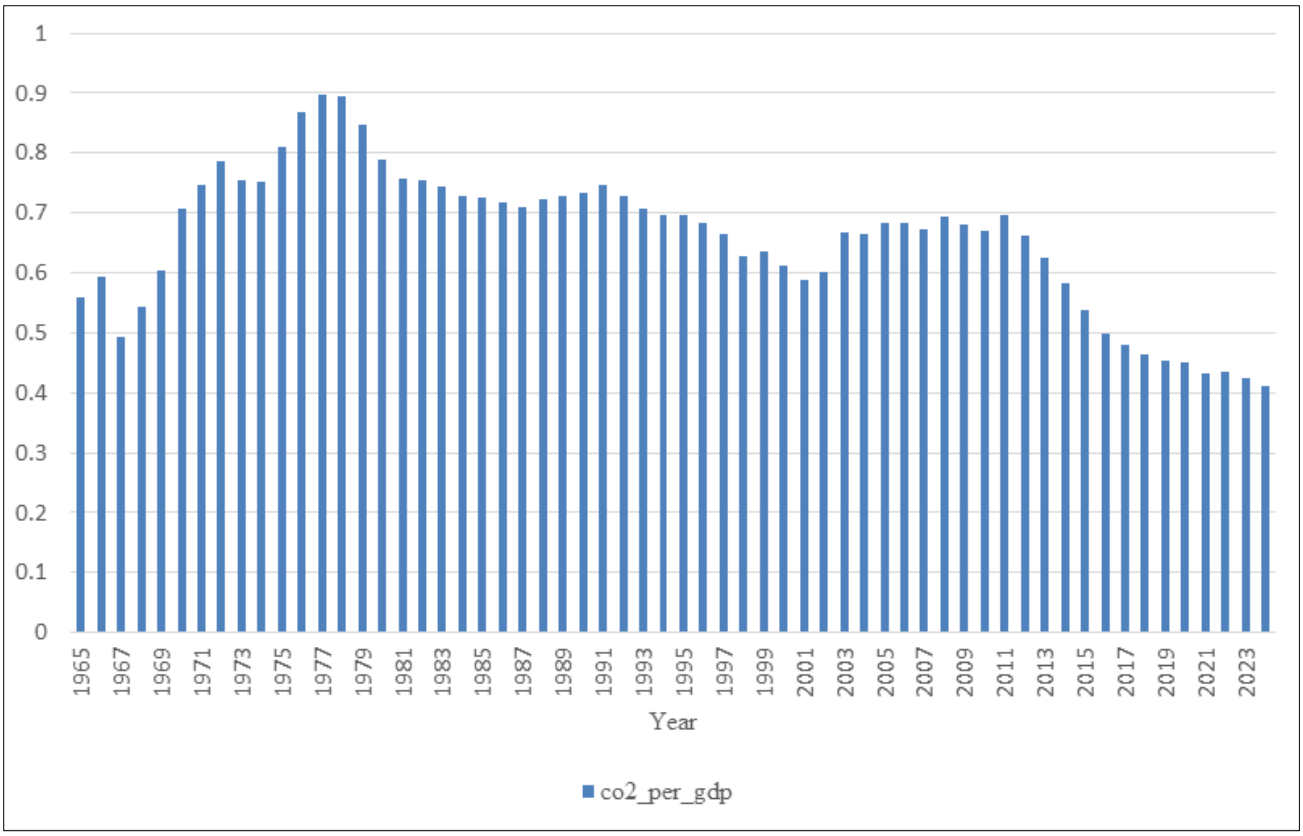

Figure 1: China's Carbon Intensity, 1965–2024
Source: OWID CO_2 Dataset [1]

From Figure 1, the information we can extract is that Chinese carnon intensity is fluctuating to get low, which means the Chinese industry structure is getting healthier. China used to be a labor intensity contry in the 1960s-2000s, while it becomes the engeneer intensity style after 2011. The Co2 per capita of China is 0.558 in 1965 and reach the peak in 1977 to 0.897. This is the period of China's opening up the country to develop the economy. After that, China's industry is evolve in high speed, and the industry structure is going to be utilized, which makes the CO2 per capita continuously go down.

China's carbon intensity is at a low level in 2024 and reached 0.412, which means China's carbon emission is under control. The Chinese government prioritize the technology and innovation, which is the engine to boost productivity and keep the high-quality GDP growth. China's corporations and government are emphasizing environmental protection. While society also attaches importance to the CO2 emission. This is the sustainable development way for China to grow and transition to a high-service or high technology-proposition society. The carbon intensity of China going down to a low level is a positive sign to enter a new era. China, as a developing country, has a heavy load to convince the concept of sustainable development to the society, cause the citizens of China are longing to earn money to support their life, while china still a middle-income country. The Co2 per GDP can reflect the china;s industry structure's utilization, which makes China's environment have a good vision in the future.

4.2 Economic Growth

Obviously. Economic growth is the most important goal for China, and the country does need to consume energy to support its operation. China's ecomomic developing in 30 years can be seen as a miracle in history. China is the second largest economy in 2025, from almost the weakest country in 1978. China is a hard-working nation, and its resilience makes it have the best quality fundamental infrastructure. China relied on the low-cost manufacturing industry at the start of reform and opening-up. China's development pathway can be emulated by other countries. From the Chinese stable development pathway, the global community can learned this experience to nurture their own countries.

[1] OWID CO_2 Dataset: https://ourworldindata.org/co2-dataset-sources

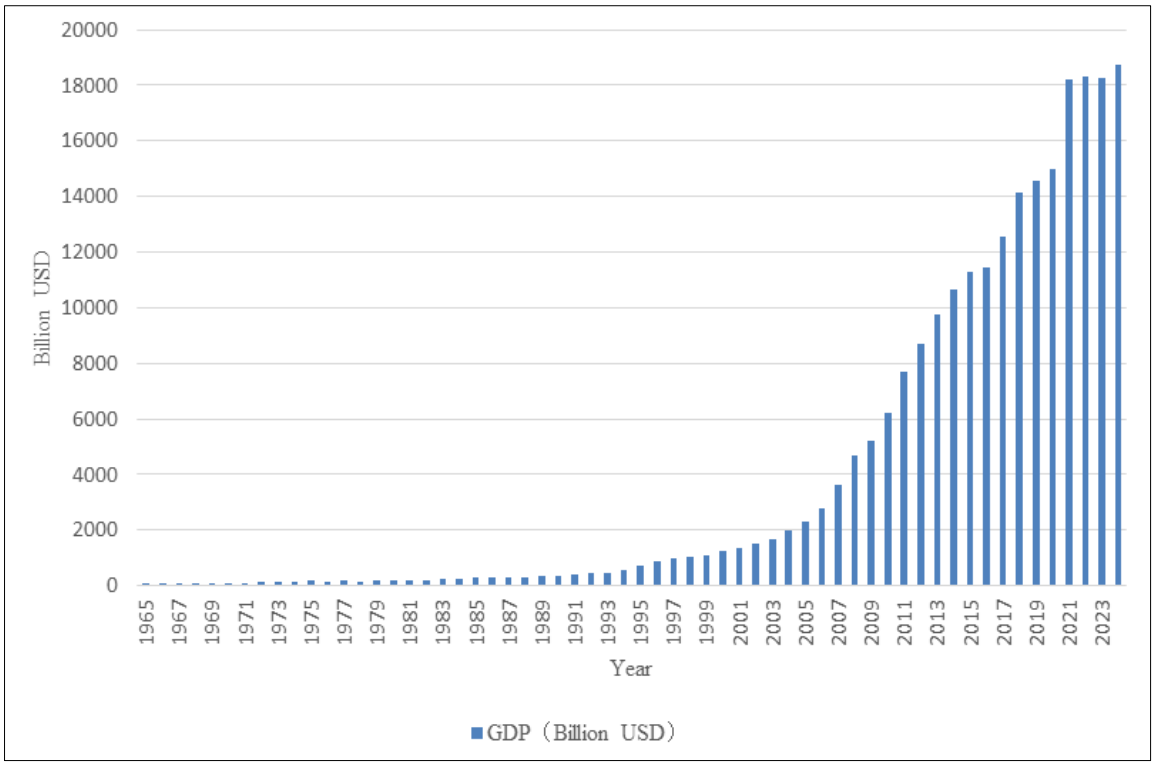

Figure 2: China's GDP Growth, 1965–2024
Source: World Bank [2]

From the above figure, we can see Chinese economic growth, and the data shows that China is going to experience a great rejuvenation. The Chinese nation has long been characteristiced as diligence and perseverance. The structure of industry transfer is also really successful, they rely on high-technology and green energy to continue boost their economy. China's infrastructure is seen as leading the world. From the actual data, we can find out that the Chinese GDP is around 70 billion USD and soaring to 18743 billion USD in 2024. We can extract the information from the figure that China's economic growth should find more fuel to keep high-speed development.

The traditional industry, which will generate exceed waster gas and carbon, should be cancelled and transferred to green energy like solar energy and tidal energy. China's new energy vehicles also decrease carbon emissions, which also let china's carbon intensity get more health.

4.3 Variable Selection and Data Sources

Using Stata software, the study employs Chinese economic data from world bank and carbon-related data from the OWID CO_2 Dataset from 1965 to 2024. The model chooses Carbon Intensity as the dependent variable and chooses Economic Growth as the independent variable. After that, the model employs Coal CO_2 Emissions per Capita, Services, Value Added (% of GDP), and Oil CO_2 Emissions as the Control Variables. The overview of variable selection is as below table 1.

Table 1: Variable Selection for the Analysis of Factors Influencing China's Carbon Intensity and Economic Growth

Variable Type	Variable Name	Indicator Selected	Symbol	Data Source
Dependent Variable	Carbon Intensity	CO_2 emissions per unit of GDP	$\ln CPD_t$	OWID CO_2 Dataset
Independent Variable	Economic Growth	GDP (current or constant USD)	$\ln GDP_t$	World Bank
Control Variables	Coal CO_2 Emissions per Capita	coal_co2_per_capita	$\ln CCP_t$	OWID CO_2 Dataset
	Services, Value Added (% of GDP)	Services, value added (% of GDP)	$\ln SVD_t$	World Bank
	Oil CO_2 Emissions	oil_co2	$\ln OCO_t$	OWID CO_2 Dataset

[2] World Bank: https://data.worldbank.org

5. Empirical Analysis

5.1 Descriptive Statistics and Empirical Testing

This study uses Name, Symbol, Sample Size, Minimum, Maximum Mean, Standard Deviation, and Median to explain the descriptive statistics of five factors. The Descriptive Statistics Results is as follows.

Table 2: Descriptive Statistics Results

Name	Symbol	Sample Size	Minimum	Maximum	Mean	Standard Deviation	Median
Carbon Intensity	$\ln CPD_t$	60	-0.887	-0.108	-0.435	0.195	-0.381
Economic Growth	$\ln GDP_t$	60	24.980	30.562	27.552	1.850	27.195
Coal CO_2 Emissions per Capita	$\ln CCP_t$	60	-0.685	1.834	0.725	0.742	0.674
Services, Value Added (% of GDP)	$\ln SVD_t$	60	3.111	4.039	3.558	0.307	3.548
Oil CO_2 Emissions	$\ln OCO_t$	60	3.555	7.456	6.079	1.014	6.105

The above table shows that the dataset has 60 rows of data and all variables are log-transformed. The dataset's Minimum and Maximum are not that extreme for the model, and the study can do the analysis the next step.

5.2 Baseline Regression Analysis

This section employs four variables, as Economic Growth, Coal CO_2 Emissions per Capita, Services, Value Added (% of GDP),. Oil CO_2 Emissions to illustrate the Carbon Intensity. The model uses OLS Regression to find the basic digital relations of their four factors to the dependent variable. In addition, the robust regression is incorporated to mitigate the effect of heteroscedasticity on the model.

Table 3: Baseline Regression Results

	(1) OLS Regression	(2) Robust Regression
Economic Growth	-0.277** (-7.809)	-0.277** (-8.070)
Coal CO_2 Emissions per Capita	0.569** (5.728)	0.569** (5.660)
Services, Value Added (% of GDP)	-0.450** (-4.048)	-0.450** (-4.208)
Oil CO_2 Emissions	0.109* (2.645)	0.109** (3.044)
Constant	7.730** (9.357)	7.730** (9.425)
Observations	60	60
R^2	0.861	0.861

Note: Dependent variable = Carbon Intensity. ***, *, and * indicate significance at the 1%, 5%, and 10% levels, respectively. t-statistics are reported in parentheses.

The above table presents the data relations of fours variable to Carbon Intensity. We can see that Economic Growth has a significant negative effect on Carbon Intensity, with the regression coefficient is -0.277 ($P < 0.05$). This means that Chinese economic development can actually reduce the carbon intensity, as Chinese industry utilizes energy consumption, which will contribute to the decrease.

In addition, the Coal CO_2 Emissions per Capita and Oil CO_2 Emissions have a significant positive effect on Carbon Intensity, and their regression coefficient is 0.569 ($P<0.05$) and 0.109 ($P<0.1$), respectively. These two factors contribute to carbon emission, cause the oil and coal are traditional energy sources, which is unefficiency and generate excessive waste when they burned uncompletely.

Last but not least, the variable of Services, Value Added (% of GDP) have significant negative effect on Carbon Intensity, with the regression coefficient being -0.450 ($P<0.05$), which means the Services industry will generate less carbon and contribute to economic growth.

To sum it up, the Economic Growth and Services, Value Added (% of GDP) are negatively associated with the Carbon Intensity, while Coal CO_2 Emissions per Capita and Oil CO_2 Emissions are vice versa.

5.3 Endogeneity Test

This section employs GDP at t-1 as an

instrumental variable, cause it is related to the independent variable while it is unrelated to the dependent variable. Lagged GDP can serve as an instrumental variable to build a GMM model to reduce the endogeneity effect of Economic Growth. The result of the endogeneity test is as follows.

Table 4: Endogeneity Test Result

	(1) GMM
Economic Growth	-0.303** (-8.745)
Coal CO_2 Emissions per Capita	0.615** (6.230)
Services, Value Added (% of GDP)	-0.403** (-3.937)
Oil CO_2 Emissions	0.108** (3.108)
Constant	8.239** (10.079)
Observations	60
R2	0.860
Adjusted R2	0.850
Wald $\chi 2$	$\chi^2(4)=379.178$, $p=0.000$

The above table presents the result of the endogeneity test, and we can see that the effect of the four factors on carbon intensity is the same as the baseline regression result. So we can conclude that Economic Growth and Services, Value Added (% of GDP) are significantly associated with carbon intensity. And Coal CO_2 Emissions per Capita and Oil CO_2 Emissions are positively significantly associated with carbon intensity.

6. CONCLUSION

6.1 Conclusion

The project of ESG is popular globally, and the carbon intensity is considered an essential factor for the country, and economic growth may decrease the carbon intensity because economic growth is fueled by industry transition. The primary and secondary industries are not as efficient as the tertiary industry. This essay can give evidence to policymakers or independent units to make decisions under sustainable development.

This study uses Stata software to conduct the analysis, and the analysis employs Chinese economic data and carbon-related data from world bank and the OWID CO_2 Dataset, respectively, from 1965 to 2024. The model chooses Carbon Intensity as the dependent variable and chooses Economic Growth as the independent variable. After that, the model employs Coal CO_2 Emissions per Capita, Services, Value Added (% of GDP), and Oil CO_2 Emissions as the Control Variables. From the empirical analysis, we can draw the conclusion that Economic Growth and Services, Value Added (% of GDP) are significantly associated with carbon intensity. And Coal CO_2 Emissions per Capita and Oil CO_2 Emissions are positively significantly associated with carbon intensity.

China is an acute evidence for the developing countries to conduct an industry transition, and the carbon intensity decrease associated with a high-quality environment, which benefits all the citizens living in the country. The air conditioning and temperature also affect the earth ecosystem indirectly. China is still investing human, political, and capital resource to the tertiary industry and is accelerating the industry transition, which boosts its economic growth. Environmental protection should be put in the right place and be associated with the quality of living standards.

6.2 Strategy

After seeing the result of the regression analysis, this study provides empirical evidence to help policymakers formulate effective low-carbon development strategies.

First of all, China or other countries should accelerate the energy transition, and this will generate more job opportunities and inhibit carbon emissions. The industry structure is essential for society in terms of the environment because the third industry is highly efficient and generates less waste in the process of operation. Solar and tidal energy are unlimited energy sources and can support a person or an industry's daily operation, which is becoming affordable with the advancement of green technology. This is the renewable and environmental energy for the earth, which should be protected by all global citizens. From the result of empirical analysis, we can still get the information that coal and oil burning will make the carbon intensity higher and it should be replaced by renewable energy step by step.

In addition, promoting industrial upgrading and structural transformation is necessary pathway for the

country. The primary and secondary industries are inefficient; they should be replaced by the tertiary industry. The proportion of the tertiary industry should get higher in the process of progress. The service sector makes a difference in society, and the country should make sure the transition of industry structure in the process. The Chinese government contribute this transition in the long term, they invest source to the high-tech and fintech sector. High productivity should be considered as the major goal for society. China is also good evidence to promote industrial upgrading. The proportion of tertiary industry add value is getting higher under the advancement of government policy.

Last but not least, strengthen low-carbon policy and market mechanisms using price or license. The corporations in the China is going to attach importance to the ESG, which is an acute duty they should shoulder in society. The government should design the carbon market to issue licenses to the corporations, which are the major organizations in the country. Many developed countries have employed a carbon license to inhibit carbon emissions. The low-carbon policy is also a powerful method to curb waste pollution; the government issues the environmental policy to balance economic growth and carbon intensity. Economic growth can be an accurate factor associated with environmental protection.

We should take the consider of Chinese nation's diligence and awareness of environmental protection. It contributes to high-speed economic growth and inhibits carbon intensity. China is on the right pathway to industry transition, and the tertiary industry will give power to china like other developed countries do. China is growing to attach more attention to the carbon intensity and high-tech sector, which will contribute the sustainable society.

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