Decomposition Analysis and Trend Prediction of Energy-Consumption CO_2 Emissions in China's Yangtze River Delta Region

○袁　月*・昔　宣希*
Yue Yuan and Sunhee Suk

1. Background and research objective

In 2019, China's yearly greenhouse gas emissions amounted to 27% of global emissions, surpassing the total emissions of Organization for Economic Cooperation and Development (OECD) countries for the first time, and in 2021 it consumed 26.49% of world primary energy and created 31.06% of global CO_2 emissions. China, as the world's largest developing country, continues to prioritize economic development, particularly regional economic development. Its most developed region, the Yangtze River Delta region, holds a crucial strategic position and is a driving force in modernizing China's economy and society. In this study, we examined the factors influencing CO_2 emissions in the Yangtze River Delta region from 2000 to 2019 using the LMDI method, and the GM (1,1) model was applied to forecast primary energy consumption and CO_2 emissions in the short term. The goal of this study was to demonstrate the potential of each influencing factor in reducing CO_2 emissions by exploring the impact of each factor on CO_2 emissions changes and predict future trends in CO_2 emissions changes to explore potential future pathways for efficient CO_2 emissions and execute low-carbon development strategies.

2. Data and research method

All available data were obtained from the China Statistical Yearbook (2001–2020), Jiangsu Statistical Yearbook (2001–2020), Zhejiang Statistical Yearbook (2001–2020), Shanghai Statistical Yearbook (2001–2020) and China Energy Statistical Yearbook (2001–2020) for the period 2000-2019.

The analysis process involves categorizing by industry sectors and energy types based on the extended Kaya decomposition method. We extended Kaya's identity, as follows:

$$C=\sum_{i,j} C_{i,j} = \sum_{i,j} \frac{C_{i,j}}{E_{i,j}} \cdot \frac{E_{i,j}}{E_i} \cdot \frac{E_i}{Q_i} \cdot \frac{Q_i}{Y} \cdot \frac{Y}{P} \cdot P = \sum_{i,j} F_{i,j} \cdot S_{i,j} \cdot I_i \cdot R_i \cdot G \cdot P$$

where i denotes sector, j denotes energy type, $C_{i,j}$ denotes carbon emission from energy j consumption by sector i (in units of 10,000 tons), $E_{i,j}$ denotes energy j consumption by sector i (in units of 10,000 tons of standard coal), E_i represents total energy consumption of sector i (in units of 10,000 tons of standard coal), Q_i represents value added of sector i (in units of 100 million yuan), Y refers to GDP (in units of 100 million yuan), and P refers to resident population (in units of million people). $F_{i,j} = C_{i,j} / E_{i,j}$ denotes the carbon emission coefficient of energy j in sector i (the carbon emission coefficient factor); $S_{i,j} = E_{i,j} / E_i$ denotes the proportion of energy j in sector i (the energy structure factor); $I_i = E_i / Q_i$ denotes energy intensity of sector i (the energy intensity factor); $R_i = Q_i / Y$ denotes sector i value added proportion in GDP (the industrial structure factor); $G = Y / P$ denotes economic output per capita in a period (the economic output factor); and P denotes resident population (the population size factor).

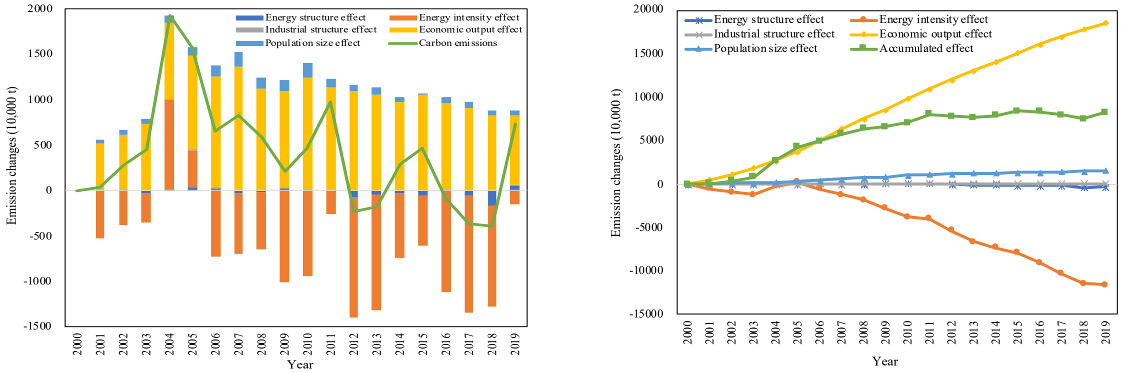
Applying the LMDI additive method, the carbon emission factors can be decomposed as below:

$$\Delta C = C^t - C^0 = \Delta C_S^t + \Delta C_I^t + \Delta C_R^t + \Delta C_G^t + \Delta C_P^t$$

* 長崎大学水産・環境科学総合研究科 Department of Environmental Sciences, Nagasaki University
〒852-8521 長崎市文教町 1-14 E-mail: isyuanyue@gmail.com

where C^0 and C^tdenote total CO_2 emissions of a region in period 0 and period t, respectively. ΔC denotes the change in CO_2 emissions from period 0 to period t. Accordingly, ΔC can be decomposed into the energy structure effect (ΔC_S), energy intensity effect (ΔC_I), industrial structure effect (ΔC_R), economic output effect (ΔC_G) and population size effect (ΔC_P).

3. Main findings



(a) **(b)**

Figure 1. (a) Time series of decomposition of CO_2 emissions of the Yangtze River Delta region, based on the five factors (compared to 2000 level); **(b)** Accumulative effect of the five factors in the Yangtze River Delta region.

Table 1. Prediction results of energy-consumption CO_2 emissions in 2020–2026 (million tons).

Year	2020	2021	2022	2023	2024	2025	2026
Predicted value	160.528	165.669	170.897	176.214	181.621	187.121	192.715

4. Conclusion

(1) Primary energy consumption and CO_2 emissions will continue to rise in the Yangtze River Delta region from 2020 to 2026, with total CO_2 emissions rising by 192.715 million tons over the forecast period;

(2) Economic output and population size have mainly positive effects on the increase in CO_2 emissions, and the impacts of changes in these two factors led to growth in CO_2 emissions. Economic output is the biggest force pulling up CO_2 emissions, contributing 224.90% in the study period. Population size is the second-most important factor promoting the growth in CO_2 emissions, the cumulative contribution ratio of which is 18.61%;

(3) Except for 2004 and 2005, energy intensity is the greatest inhibitory factor in reducing CO_2 emissions, with a significant negative effect. The energy intensity effect contributed −140.27% to the change in CO_2 emissions;

(4) Energy structure and industrial structure have insignificant contributions to CO_2 emissions, contributing −3.75% and 0.51%, respectively. Although energy structure had a positive and negative effect during the study period, it showed a negative effect in terms of the cumulative contribution. Industrial structure had a positive effect on CO_2 emissions except in 2007, although the pull effect was not significant;

(5) Changes in energy structure and energy intensity had a restraining effect, but they were insufficient to counteract the rise in CO_2 emissions, which led to an overall trend of rising CO_2 emissions.

References

Song, S.; Long, J.; Jiang, H.; Ran, B.; Yao, L. Characteristics of Office Lighting Energy Consumption and Its Impact on Air Conditioning Energy Consumption. *Energy Built Environ.* 2023, *in press*.

Wu, P.; Song, Y.; Zhu, J.; Chang, R. Analyzing the Influence Factors of the Carbon Emissions from China's Building and Construction Industry from 2000 to 2015. *J. Clean. Prod.* 2019, *221*, 552–566.